Results from the beam test of large area CsI-TGEM – based RICH prototype

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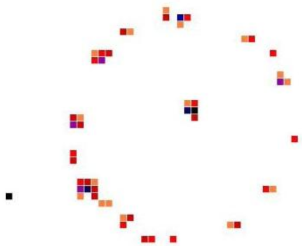
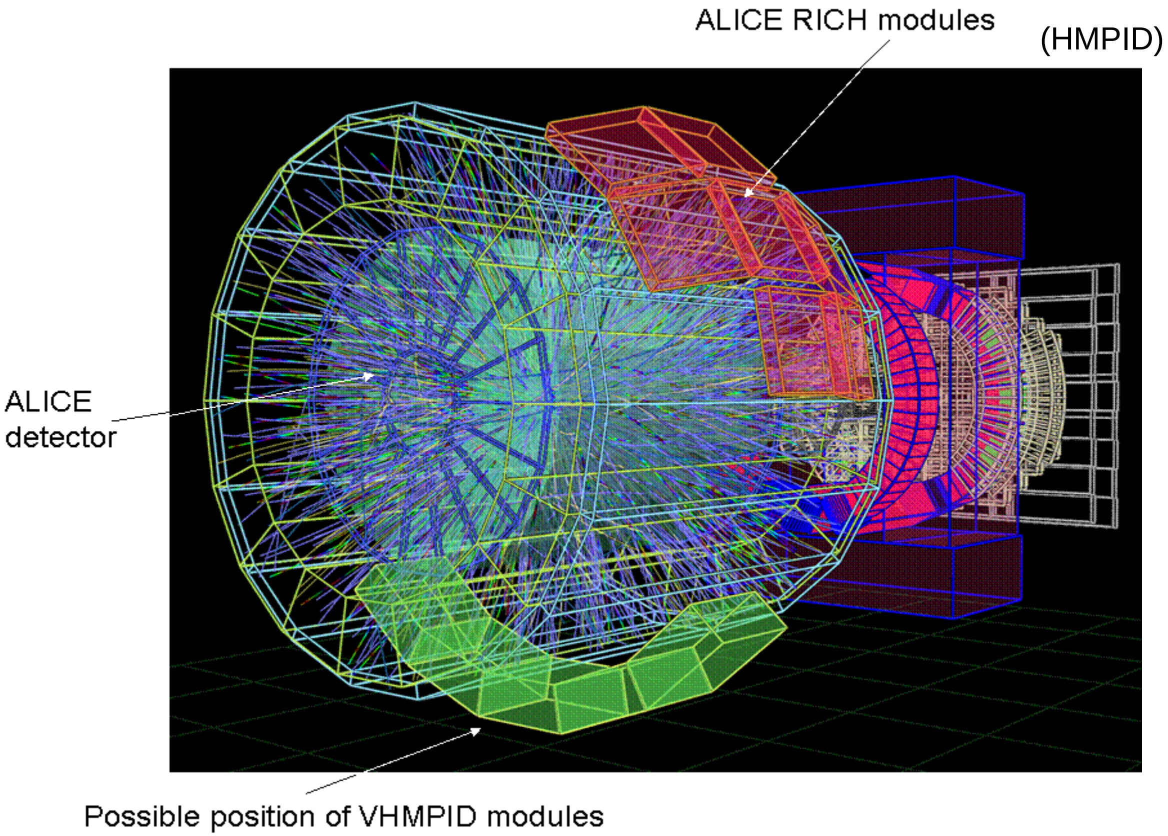


This work is motivated by the
ALICE RICH upgrade program

A few words about the evolution of the ALICE RICH upgrade program…

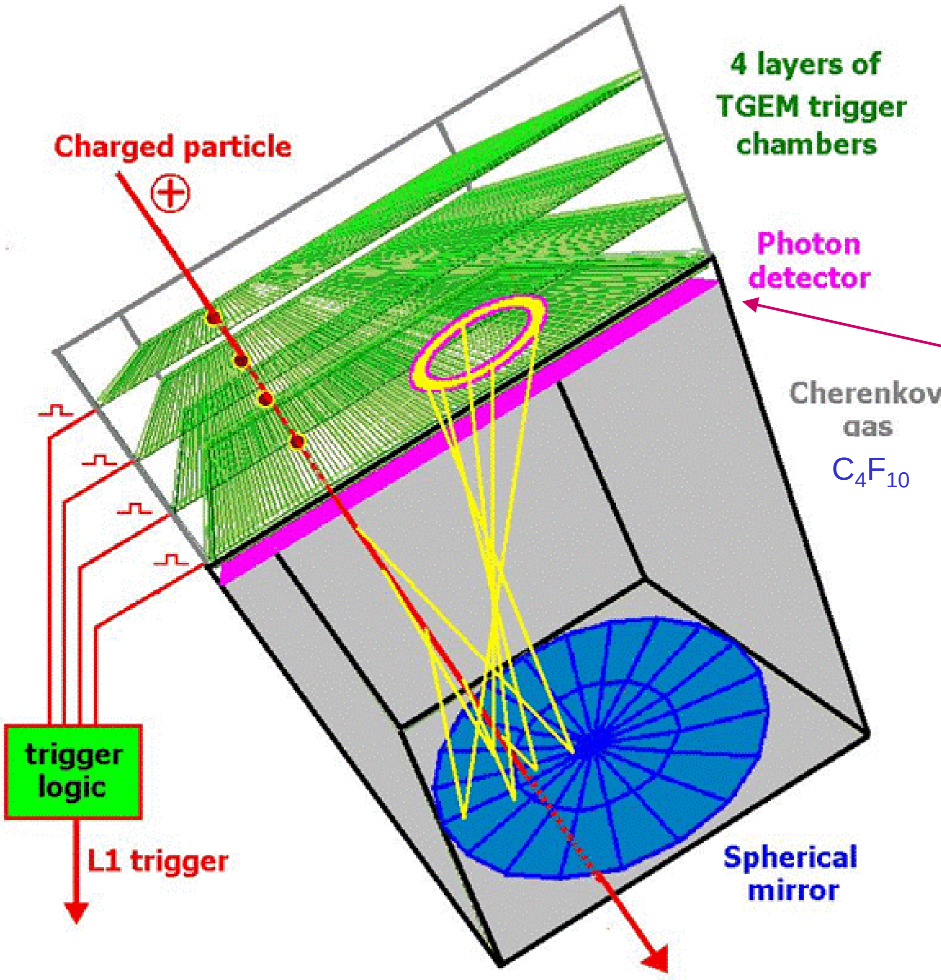
Original plans…

The original plans were to build a new RICH detector allowing to extend the particle identification for hadrons up to 30GeV/c .**It was called VHMPID.**



The **VHMPID** should be able to identify, on a track-by- track basis, protons enabling to study the leading particles composition in jets (correlated with the $\pi 0$ and /or γ energies deposited in the electromagnetic calorimeter).

The suggested detector consists of a gaseous radiator (for example, CF_4 or C_4F_{10}) and a planar gaseous photodetector



The key element of the VHMPID is a planar photodetector

However, now the upgrade program is changed: the plans are to build a high pressure RICH (to <u>cover large momentum range</u>) placed in front of calorimeter

The length of the VHMPID is limited to ~60 cm, which puts a more strict limit on the size of the photodetector

Version 17.0

EUROPEAN LABORATORY FOR PARTICLE PHYSICS

CERN-ALICE-2011-00X
ALICE-I-XXX
November, 17 2011

Letter of Intent

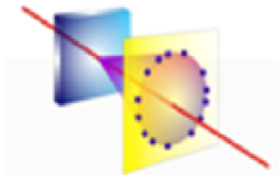
A Very High Momentum Particle Identification Detector (VHMPID) for ALICE

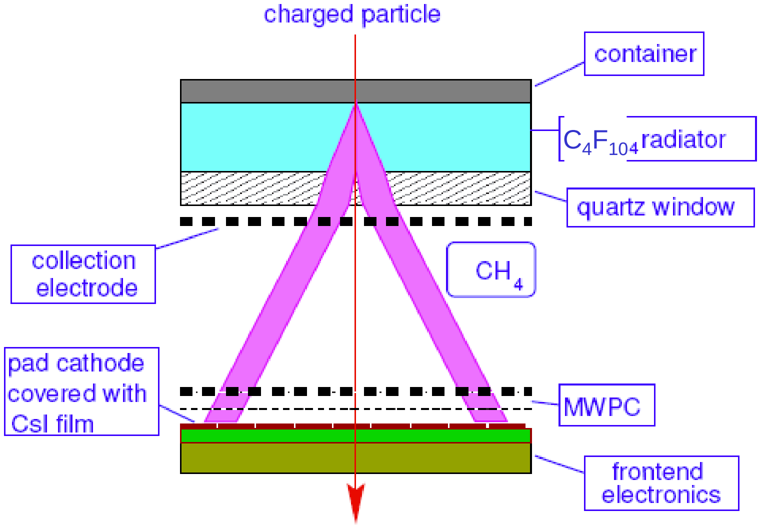
By the participating institutions

The LOI is ready to be submitted to the ALICE committee

electronic version:
https://twiki.cern.ch/twiki/bin/view/Sandbox/VHMPIDLoI

There are **two** options for planar photodetectors which are included into the LOI:



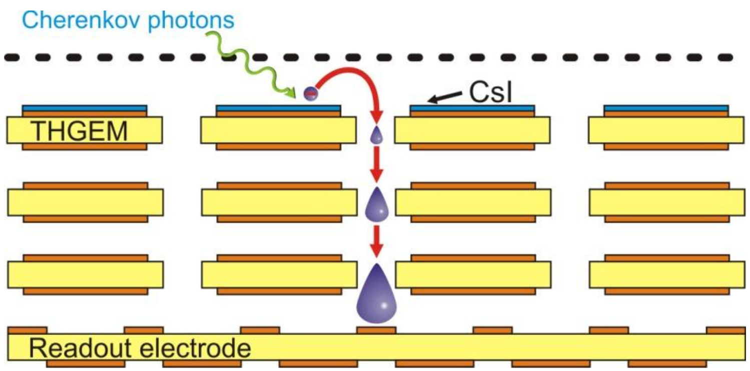


← **MWPC**

(similar to one used in ALICE RICH)

or

TGEMs/RETGEMs →

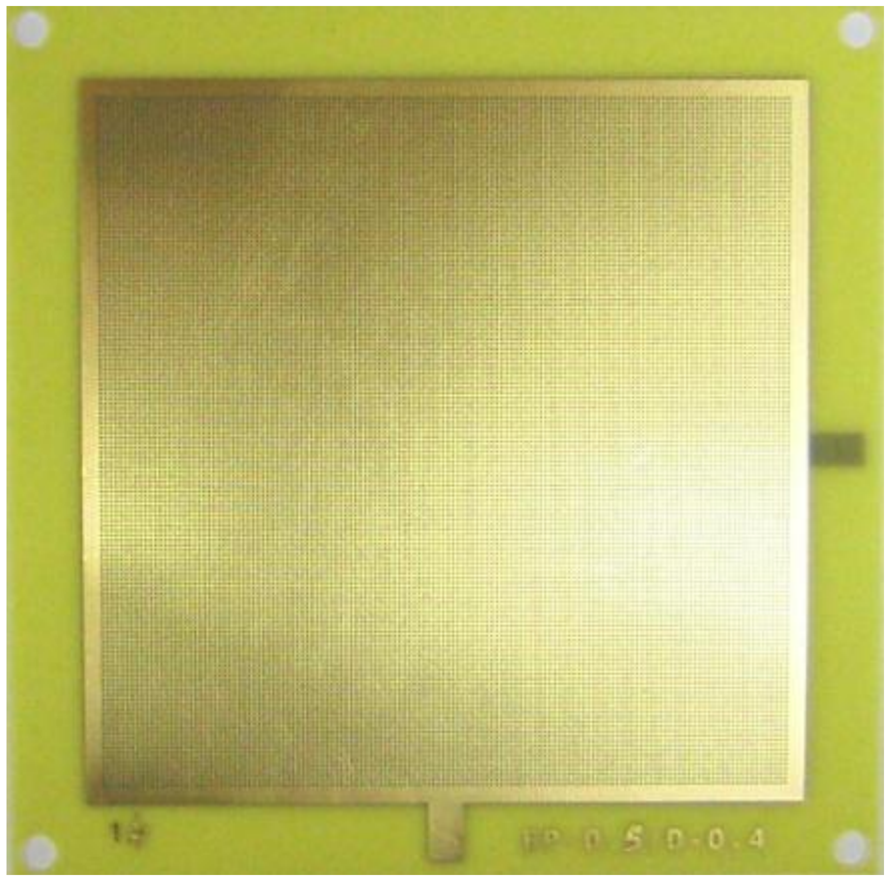


For TGEM see : *L. Periale et al., NIM A478,2002,377, S. Chalem et al., NIM A558, 2006, 475*

The aim of this work is to build a CsI-TGEM based RICH prototype, perform it beam test and compare to the MWPC approach

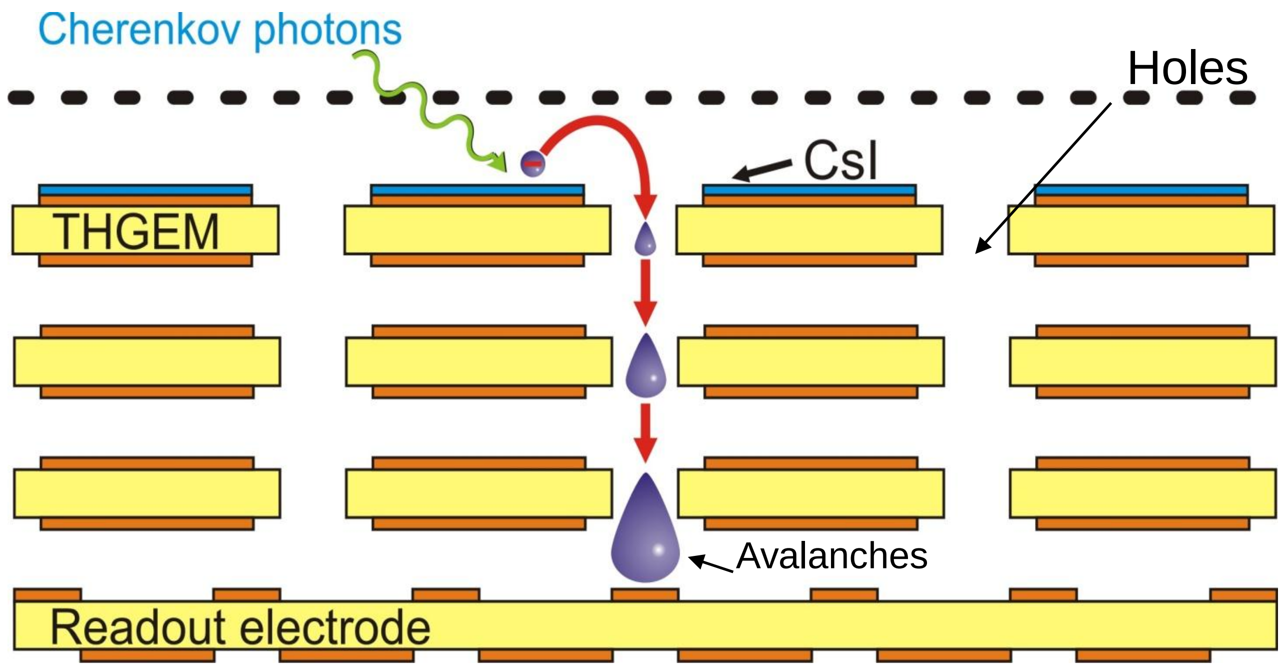
TGEMs we used

Thickness: 0.45 mm
Hole d: 0.4 mm
Rims: 10 μm
Pitch: 0.8 mm
Active area: 77%

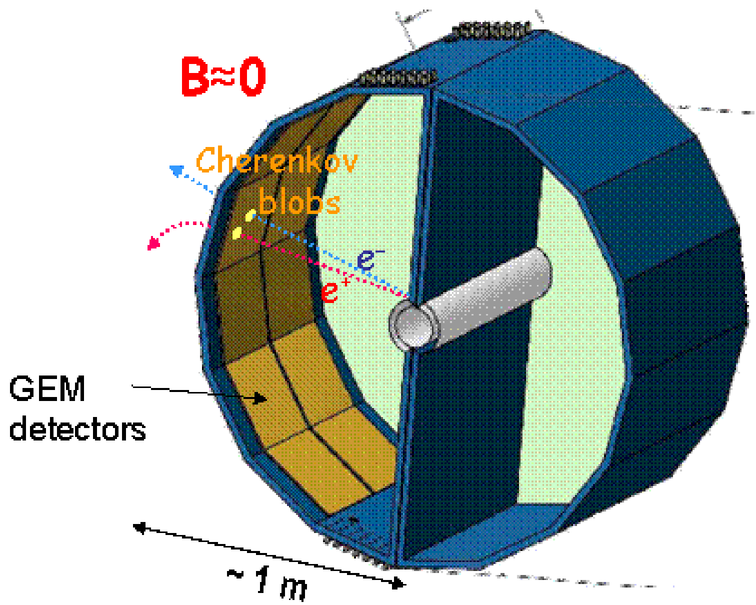


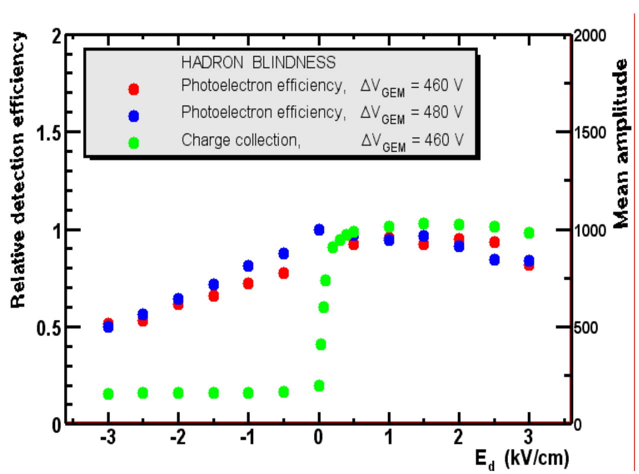
100mm

From these TGEMs six triple TGEMs were assembled



Recall, that TGEMs have several attractive features compared to ordinary GEMs:
1) ~10 times higher gains
2) robustness- capability to withstand sparks without being destroyed
3) it is a self- supporting mechanical structure making their use convenient in large detectors





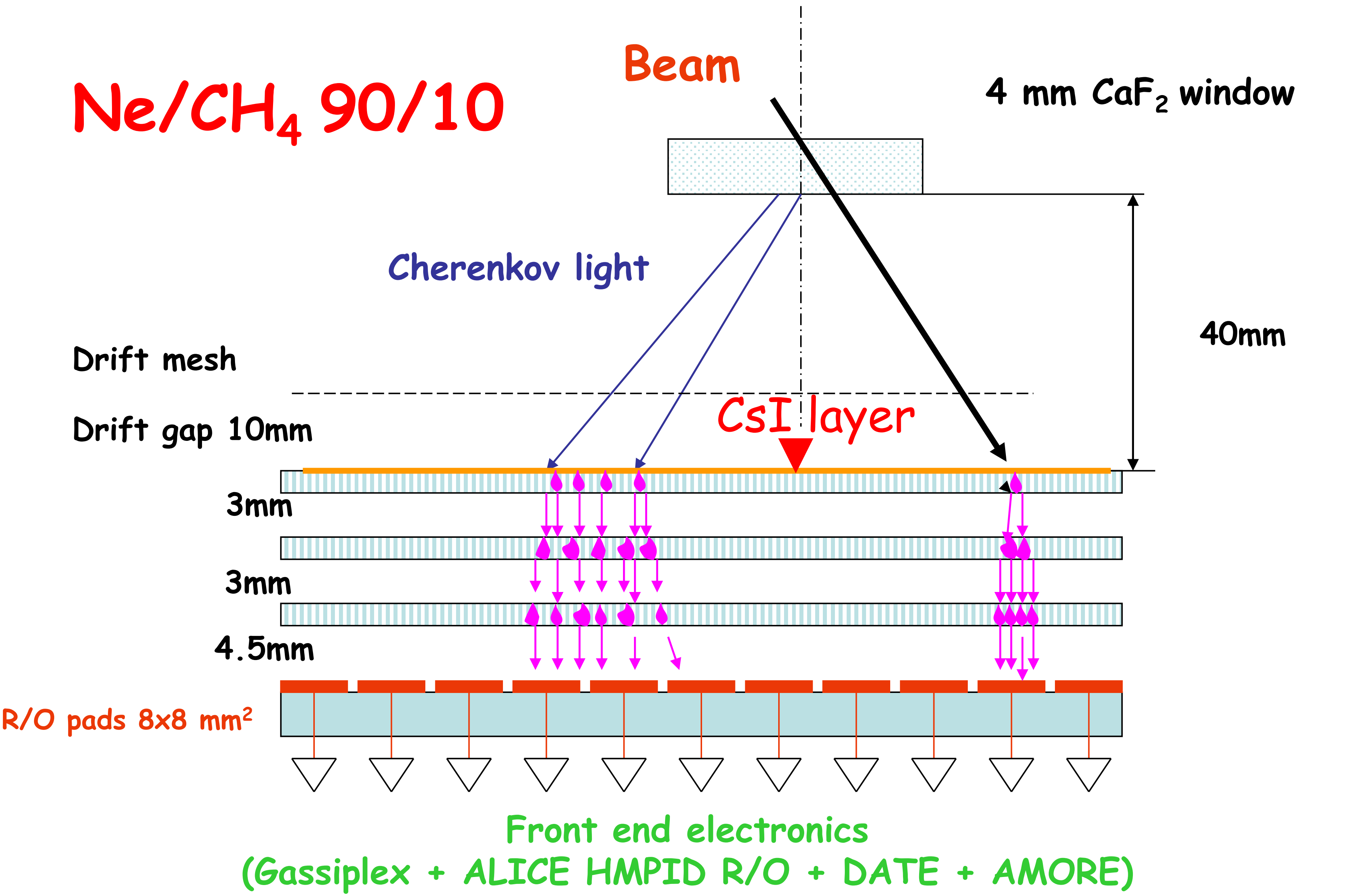
CsI-TGEMs, have some advantages, over MWPC for example:

- CsI-TGEM can operate in badly quenched gases as well as in gases in which are strong UV emitters. This allows to achieve high gains <u>without feedback</u> problems. This also opens a possibility to use them in <u>unflammable</u> gases or if necessary using windowless detectors (as in PHENIX)
- In some experiments, if necessary CsI-TGEMs, can operate in "handron blind mode" with zero and even reversed electric field in the drift region which allows strongly suppress the ionization signal from charged particles (PHENIX)

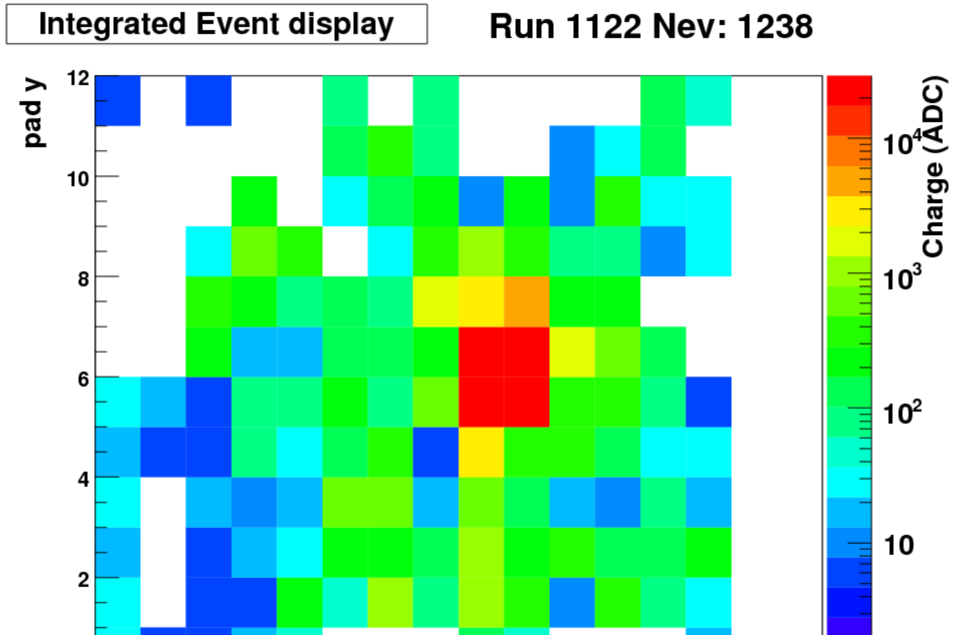
<u>Three</u> beam tests were already done

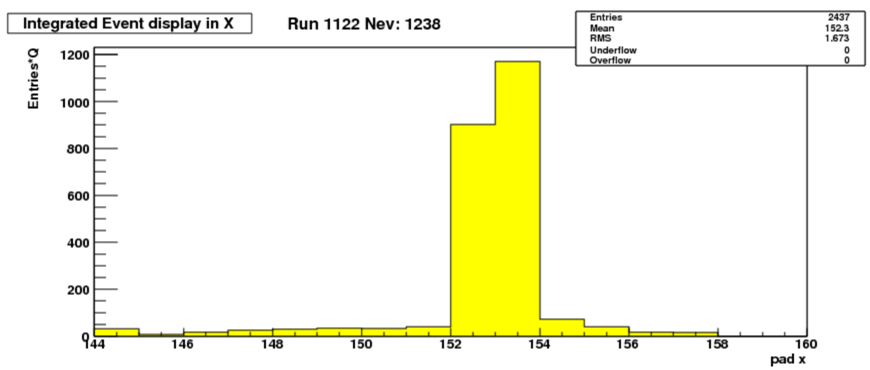
First beam test was done in summer 2010 with a CaF_2 radiator

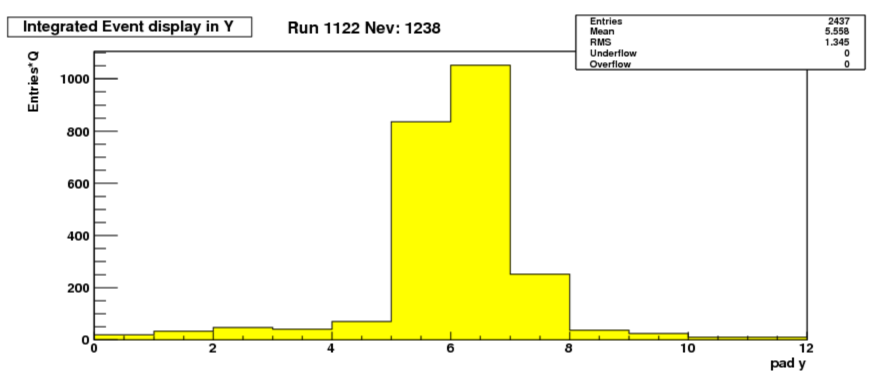
Prototype layout

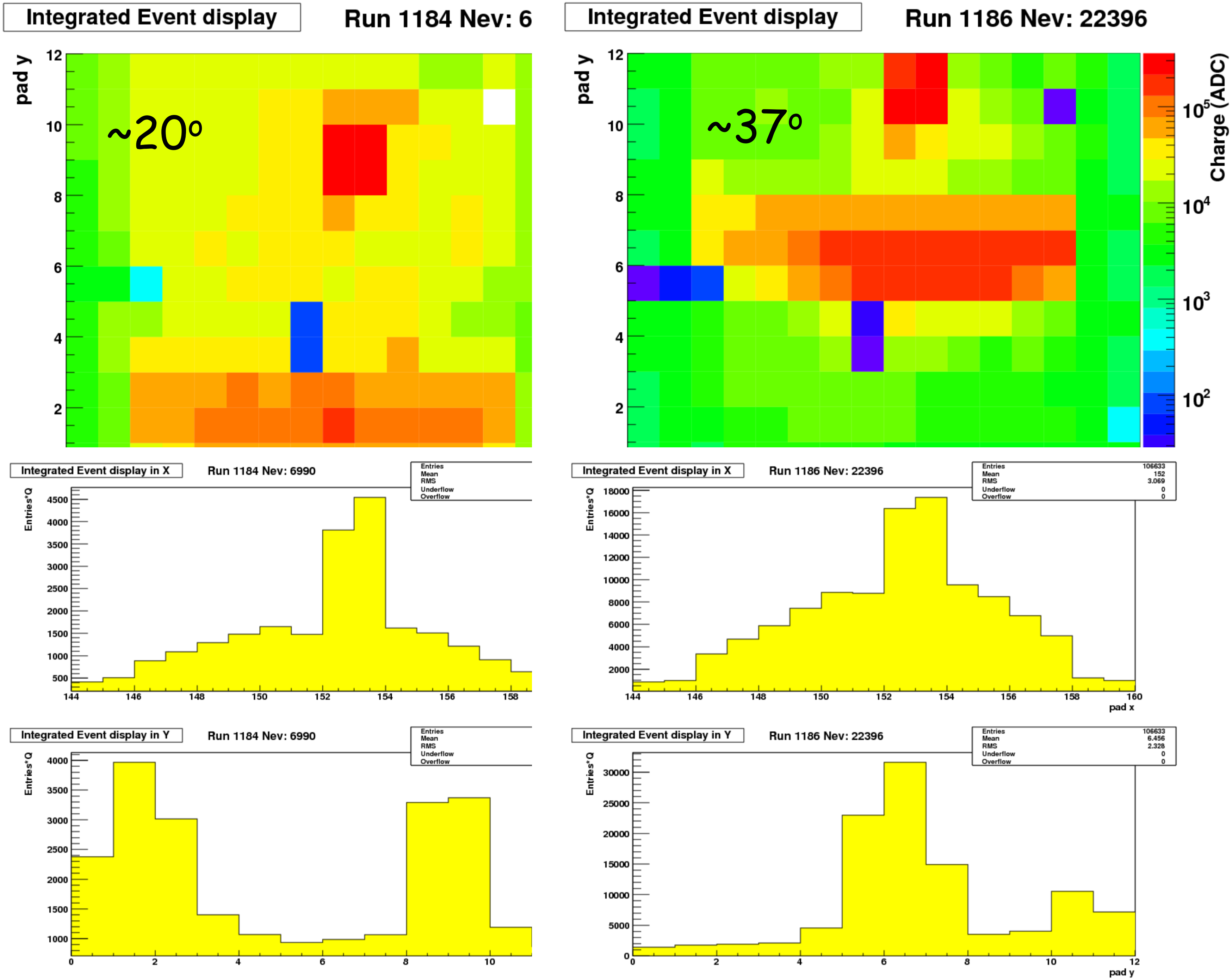


Beam perpendicular

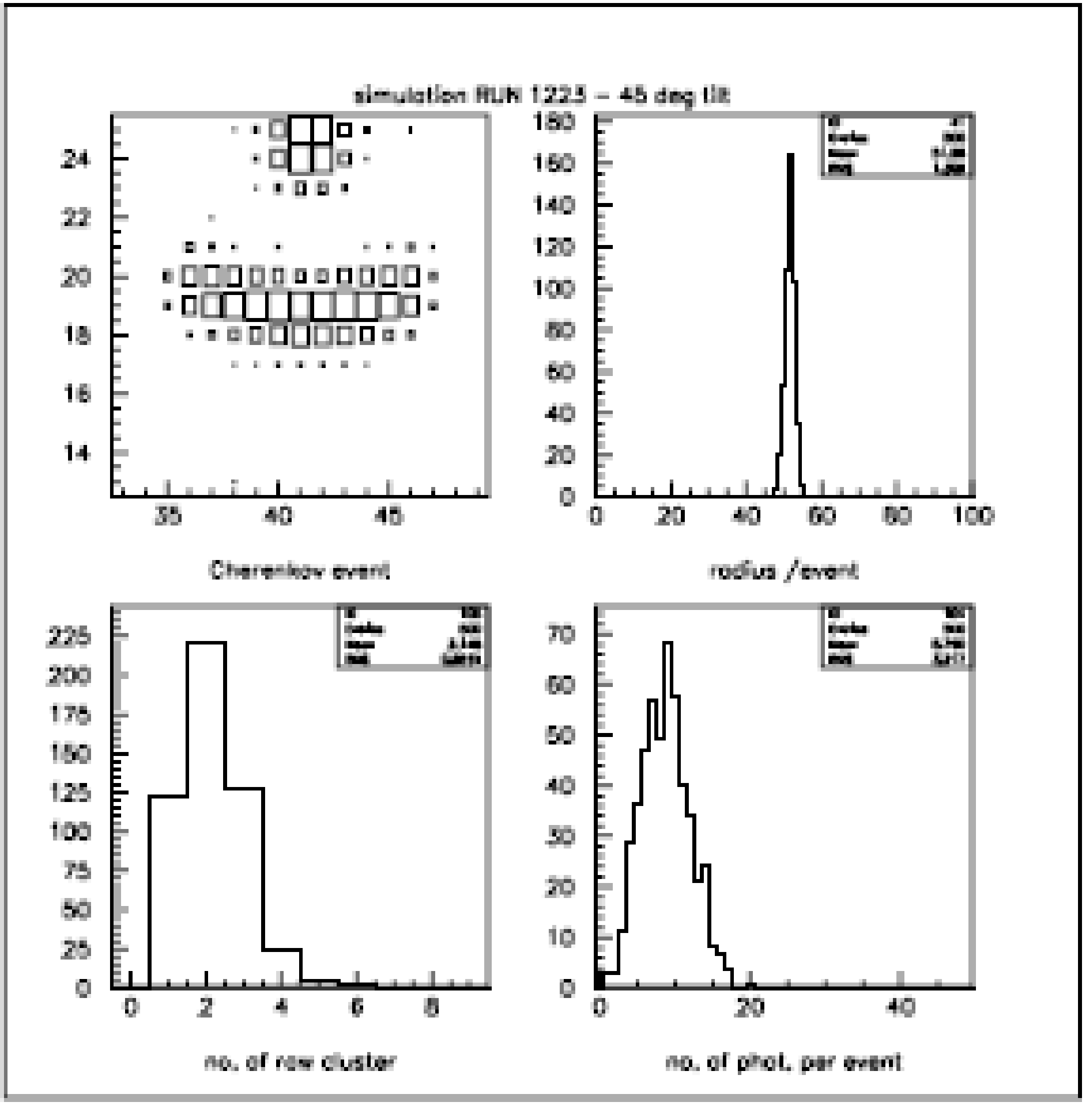







Integrated Event display
Run 1184 Nev: 6
~20°
pad y
Integrated Event display
Run 1186 Nev: 22396
~37°
pad y
Charge (ADC)
Integrated Event display in X
Run 1184 Nev: 6990
Entries
Mean
RMS
Underflow
Overflow
Entries*Q
Integrated Event display in X
Run 1186 Nev: 22396
Entries 106633
Mean 152
RMS 3.069
Underflow 0
Overflow 0
Entries*Q
pad x
Integrated Event display in Y
Run 1184 Nev: 6990
Entries
Mean
RMS
Underflow
Overflow
Entries*Q
Integrated Event display in Y
Run 1186 Nev: 22396
Entries 106633
Mean 6.456
RMS 2.328
Underflow 0
Overflow 0
Entries*Q
pad y

Monte Carlo simulations well reproduce the experimental data

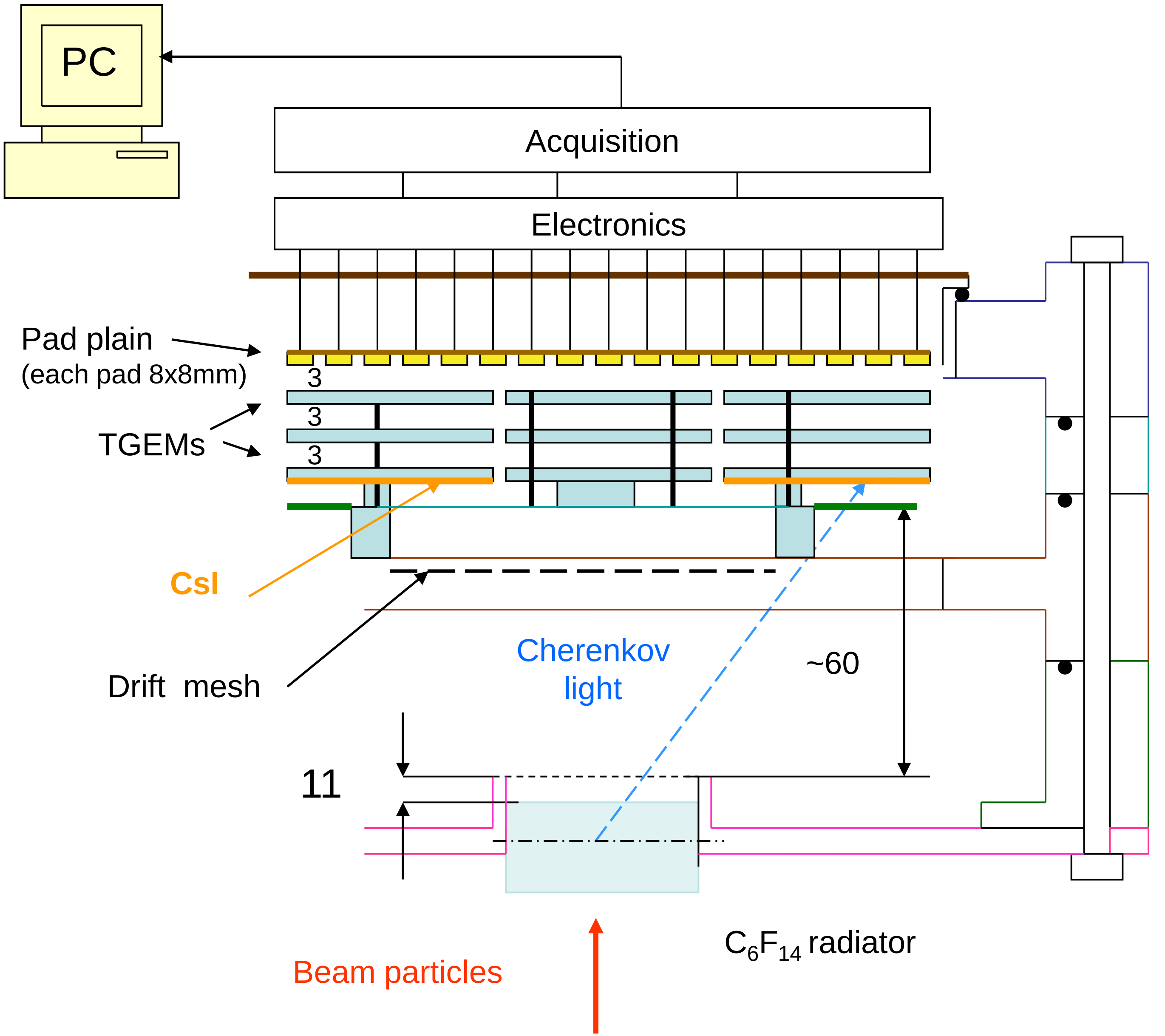


Analysis of the beam test data shows that for the given geometrical layout the QE of TGEM (after geometrical corrections) is compatible to one of the HMPID (which confirms the scan data!)

Second beam test was done in November 2010 with a 15 mm thick liquid C_6F_{14} radiator

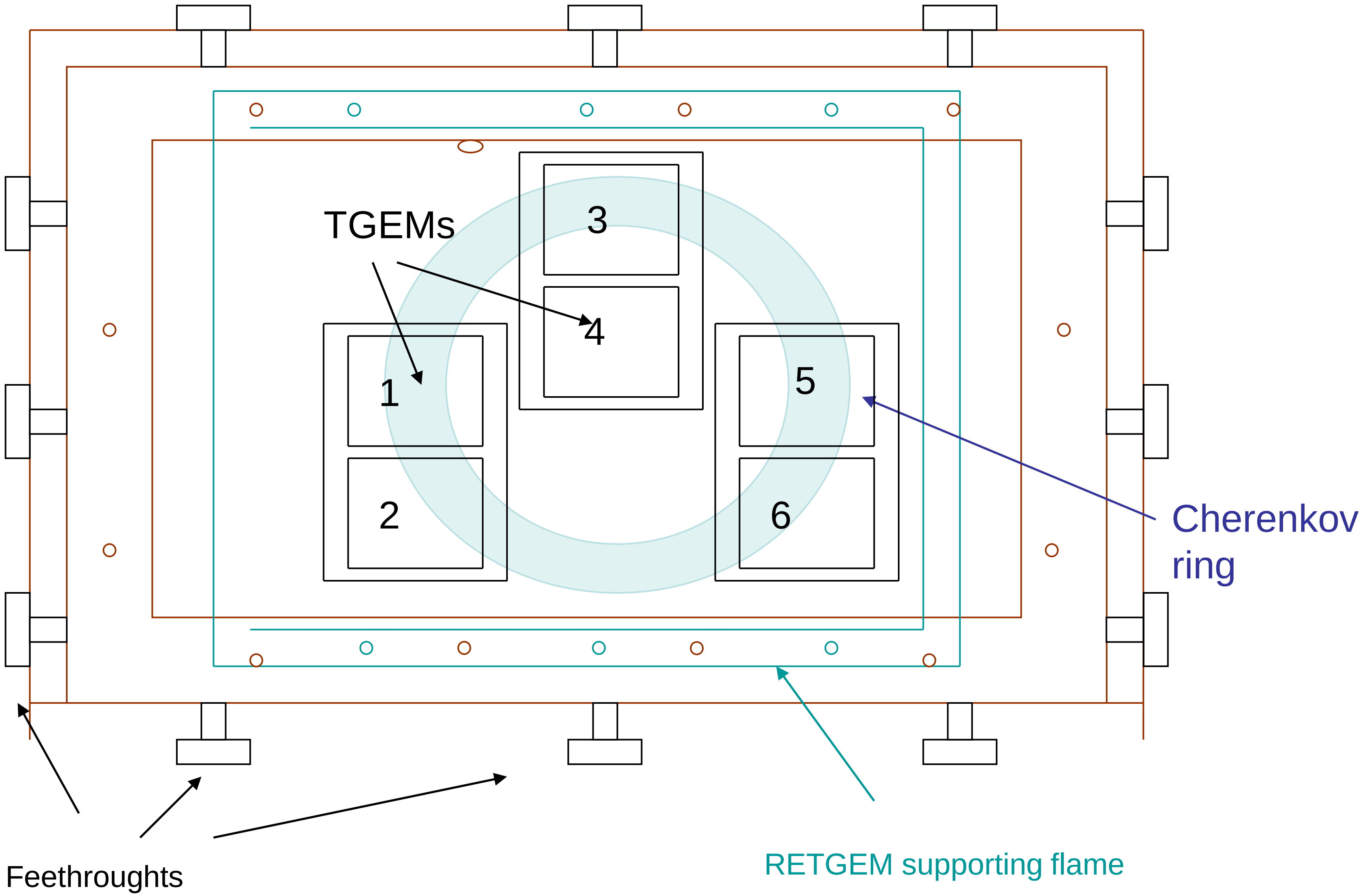
This allowed to correctly compare CsI-TGEMs with a CsI-MWPC

Design of the CsI-TGEM based RICH prototype

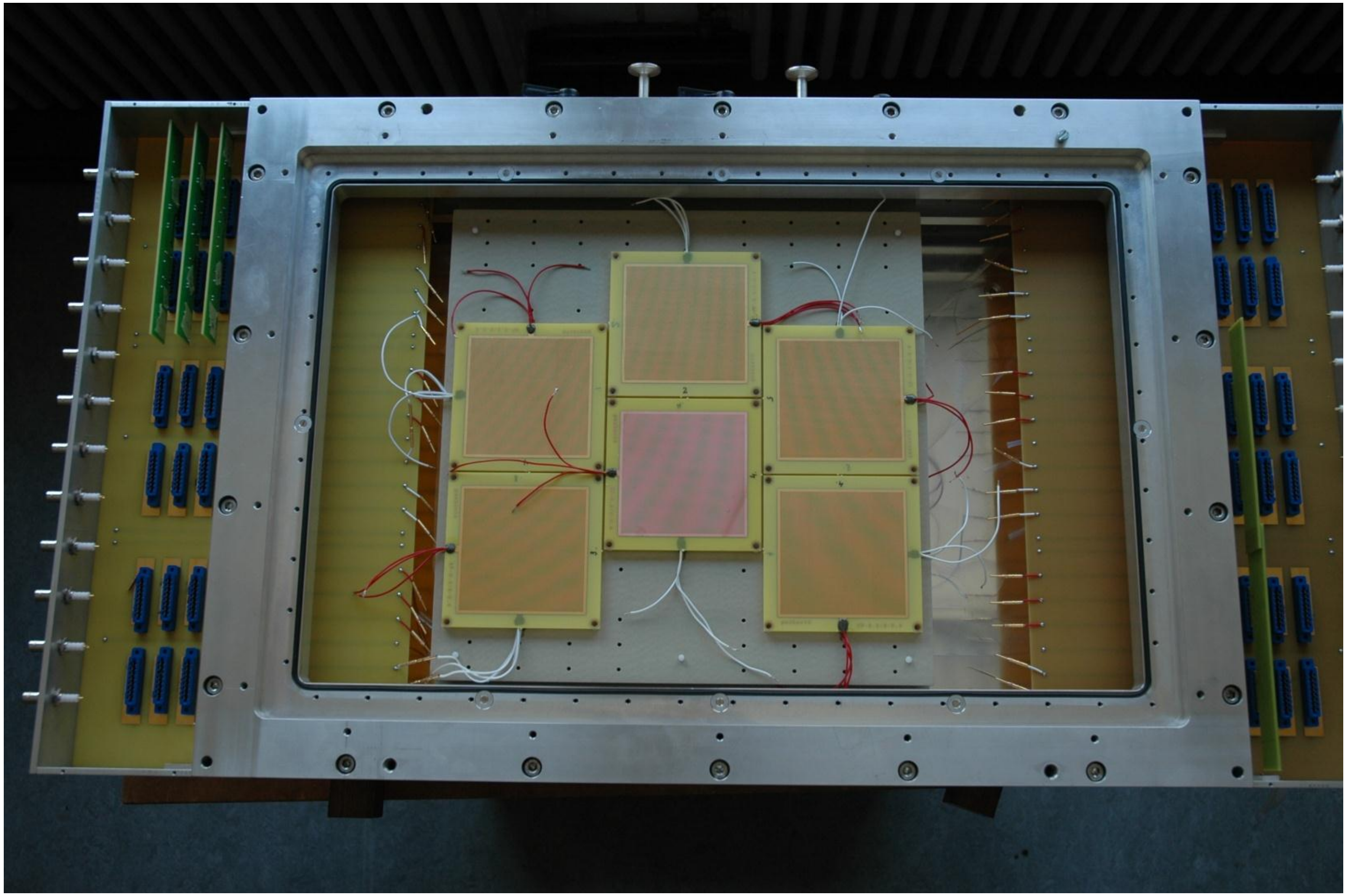


PC
Acquisition
Electronics
Pad plain
(each pad 8x8mm)
3
3
3
TGEMs
CsI
Drift mesh
Cherenkov
light
~60
11
C_6F_{14} radiator
Beam particles

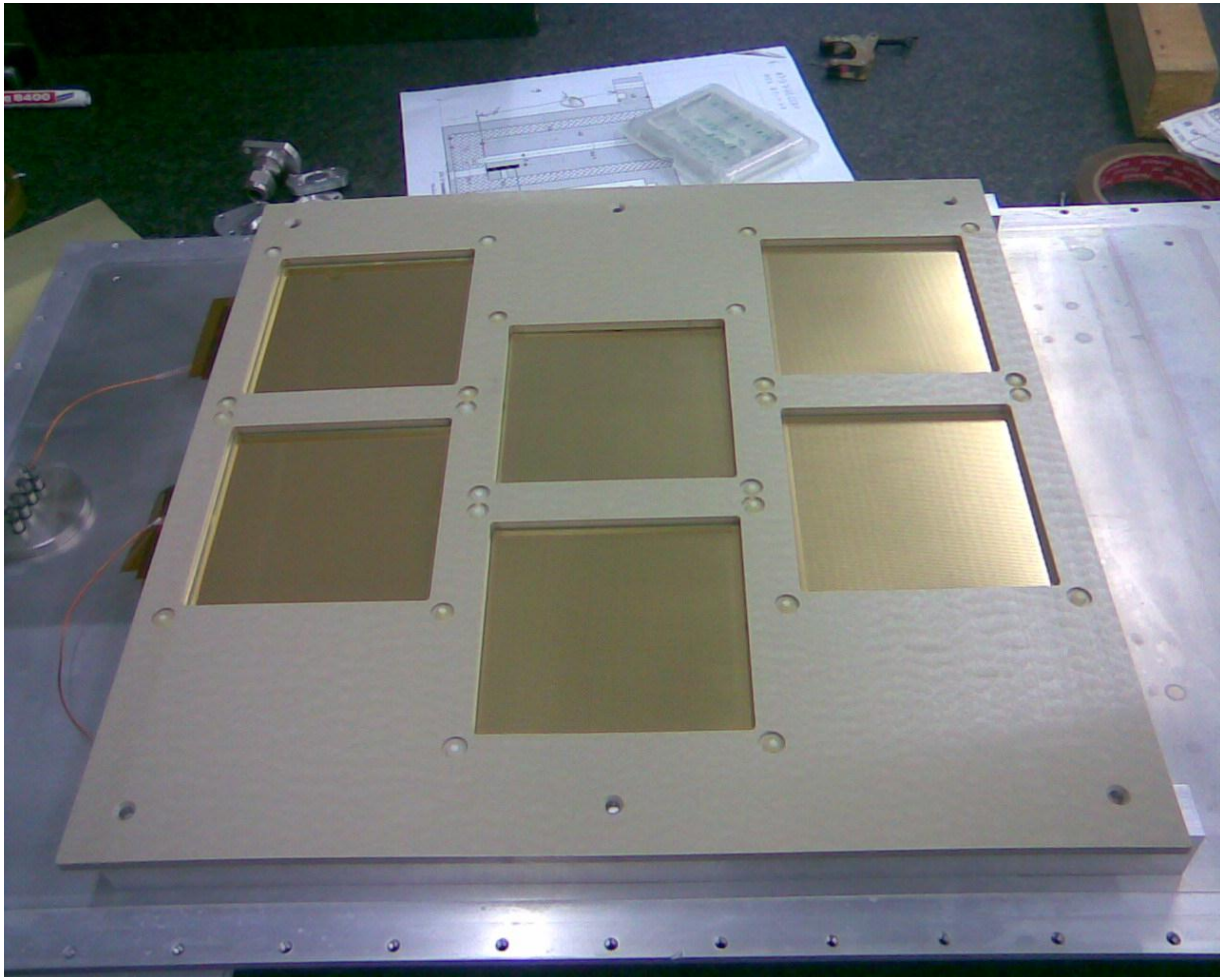
The top view of the RICH prototype (from the electronics side)



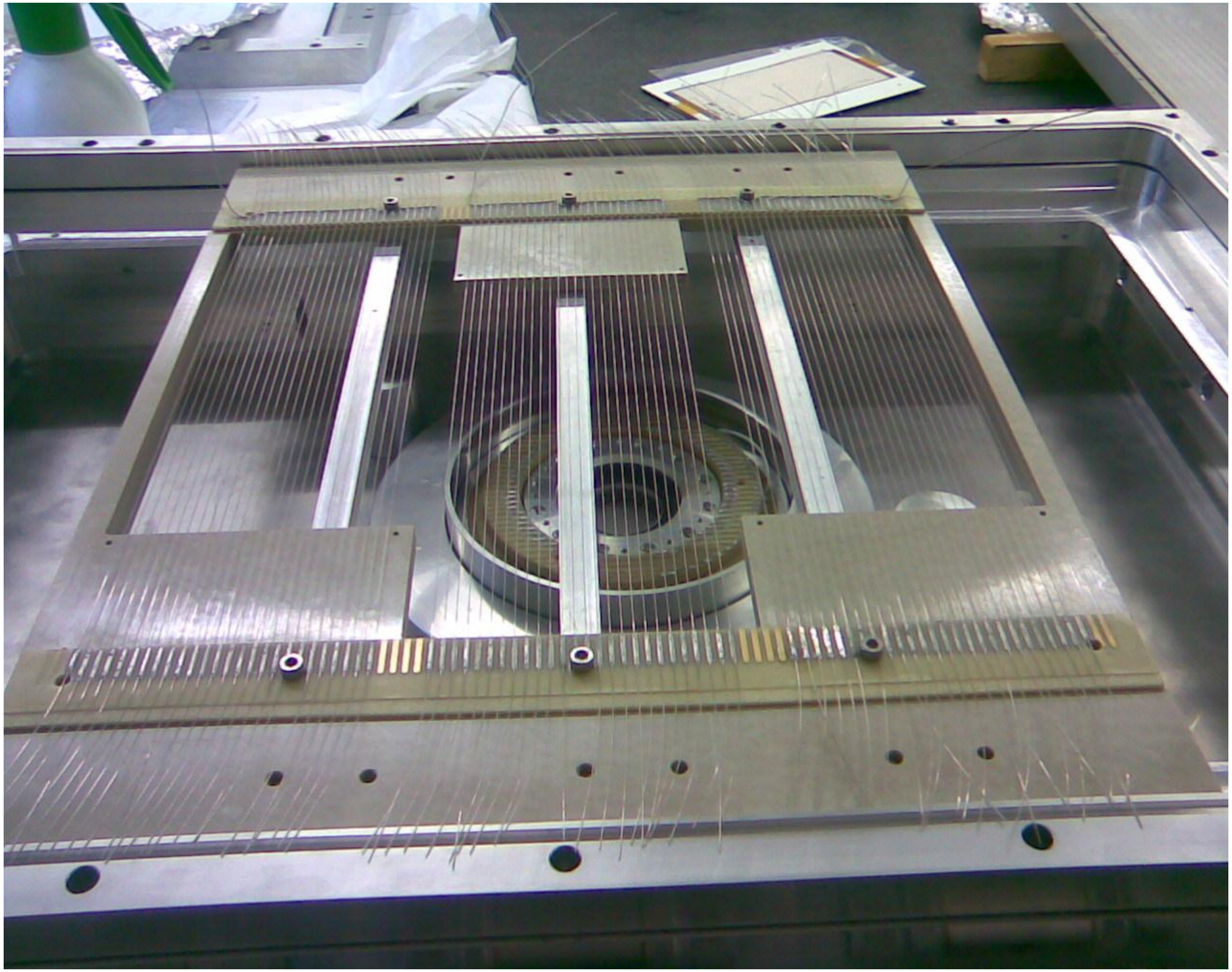
View from the back plane



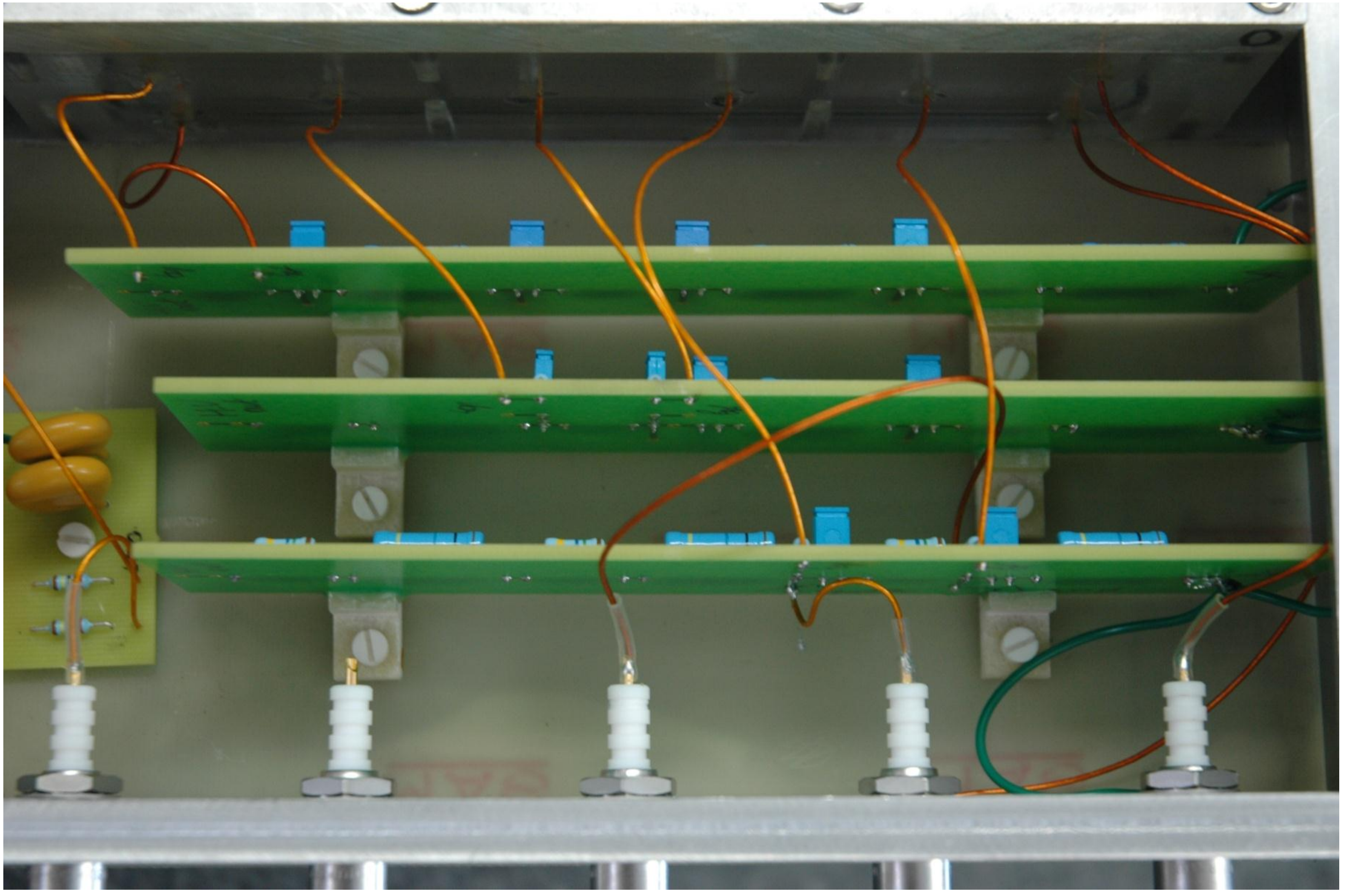
CsI side



Drift meshes (three independent grids)



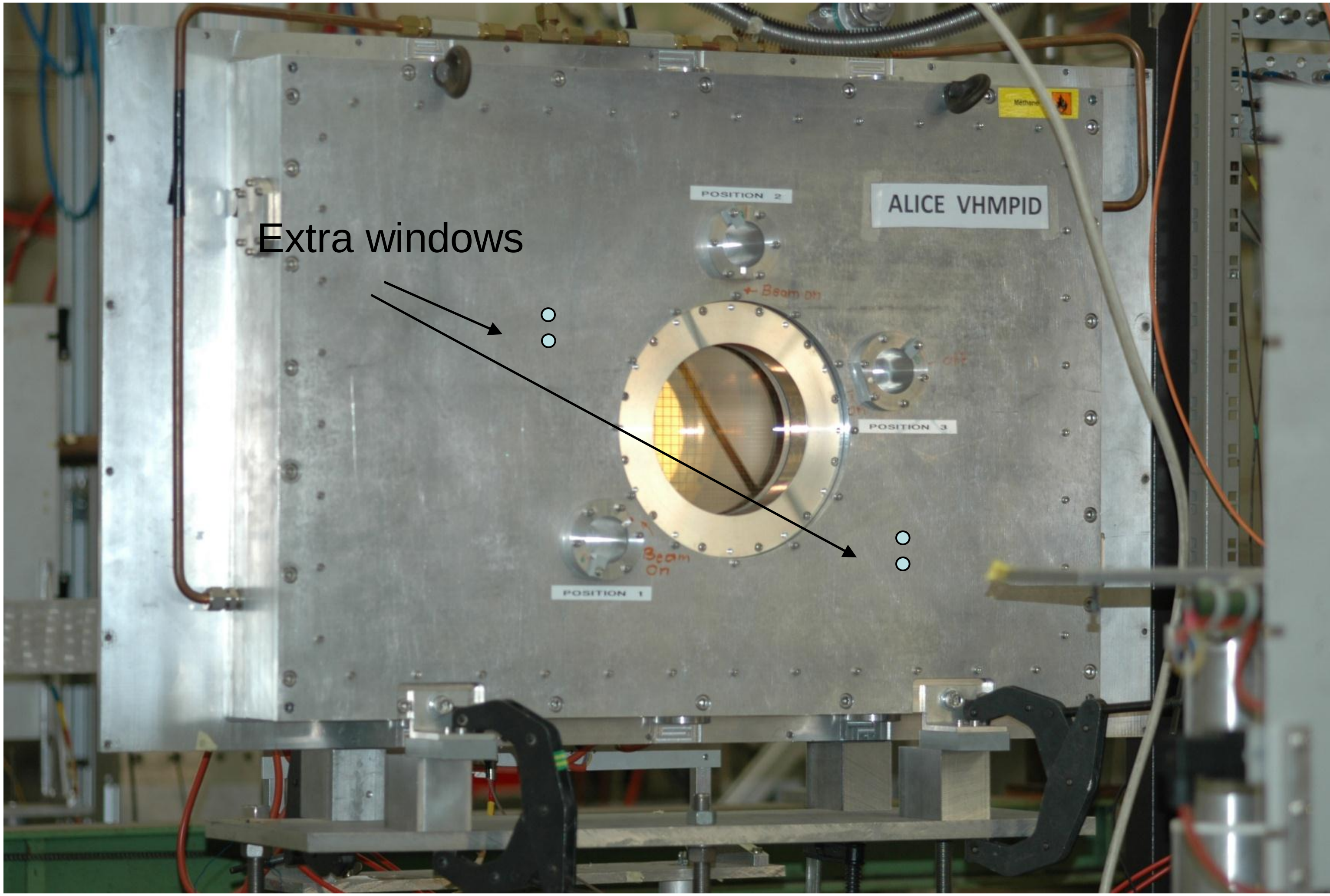
Voltage dividers



There was a possibility to independently observe analog signals from any of electrodes of any TGEM and if necessary individually optimize voltages on any TGEM

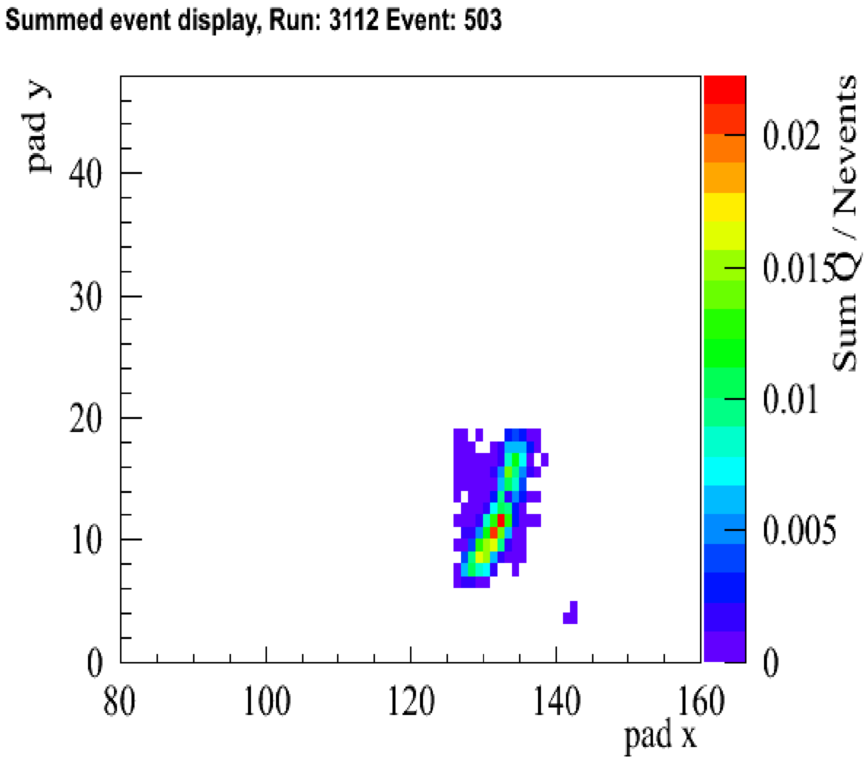
Six triple TGEMs were assembled using a glow box inside the RICH prototypes gas chamber.

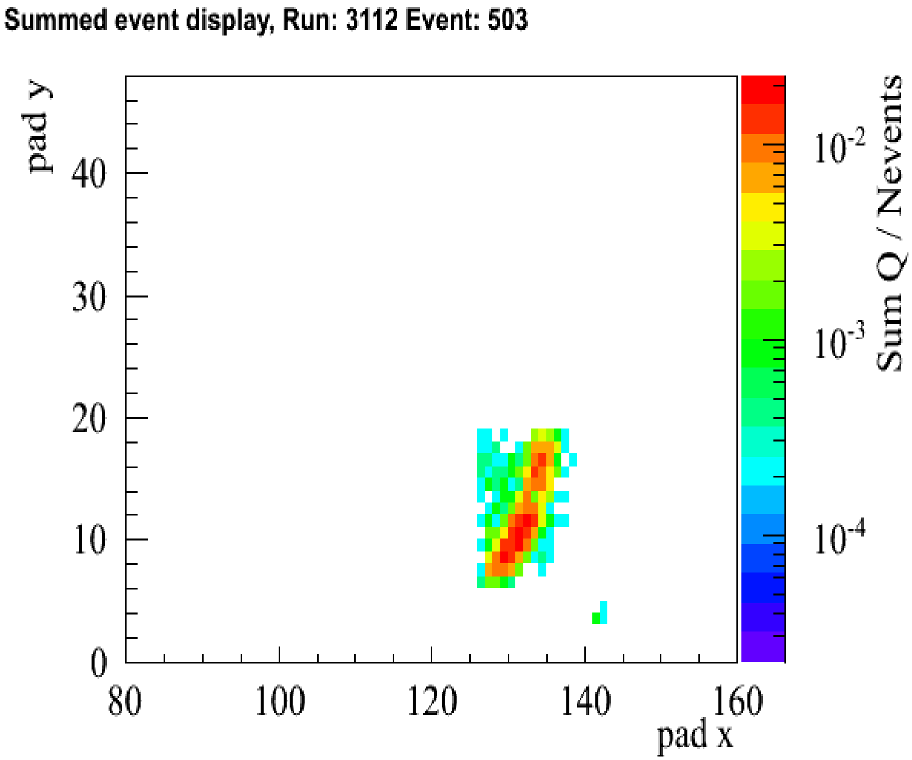
Front view



The RICH prototype has windows in front of each triple TGEM allowing to irradiate the detectors ether with the radioactive sources such as ^{55}Fe or ^{90}Sr or with he UV light from a Hg lamp

Runs with GEM 6 only

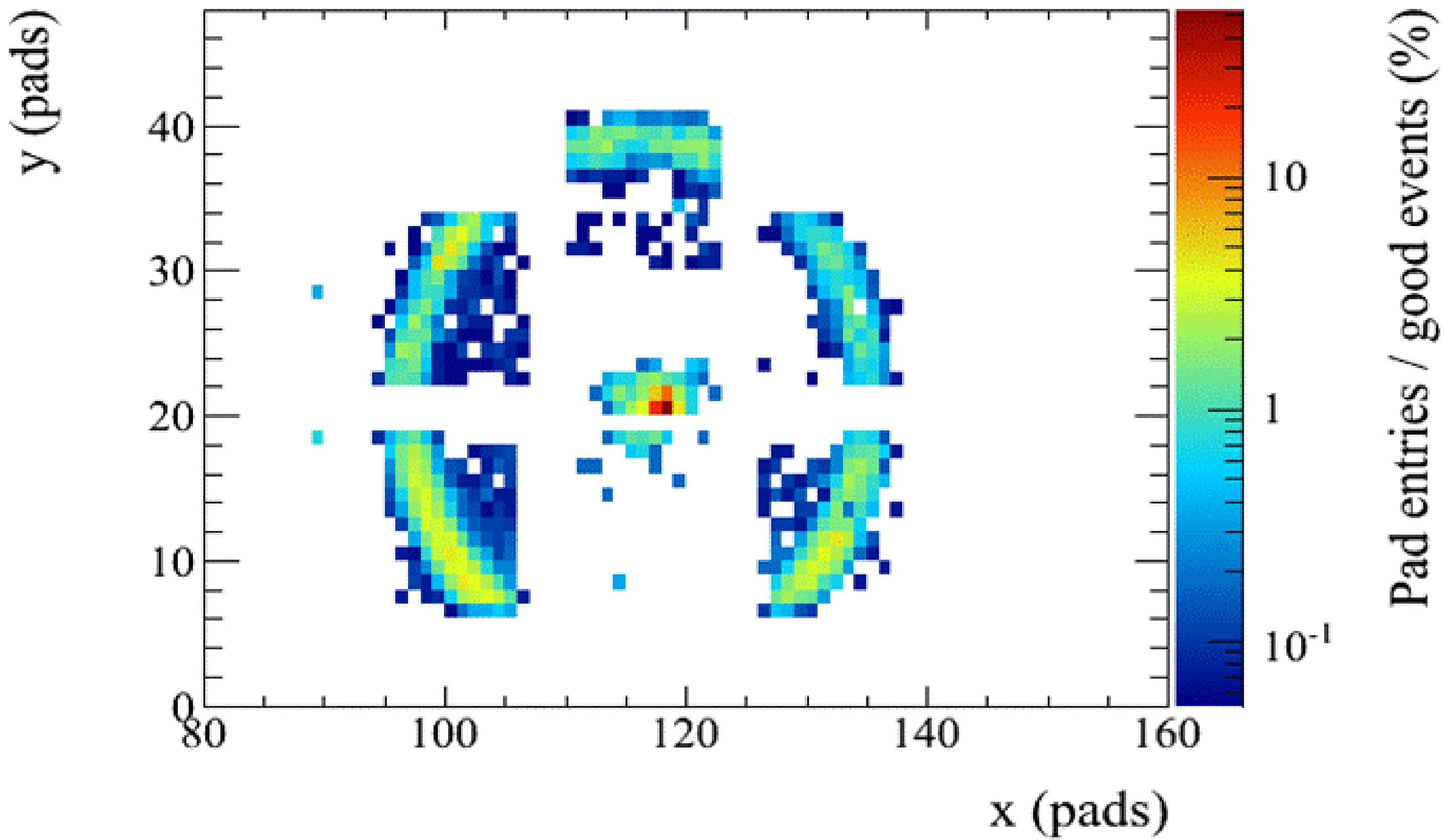




At this beam test we were parasitic user sand could test only GEM by GEM and with limited statistics

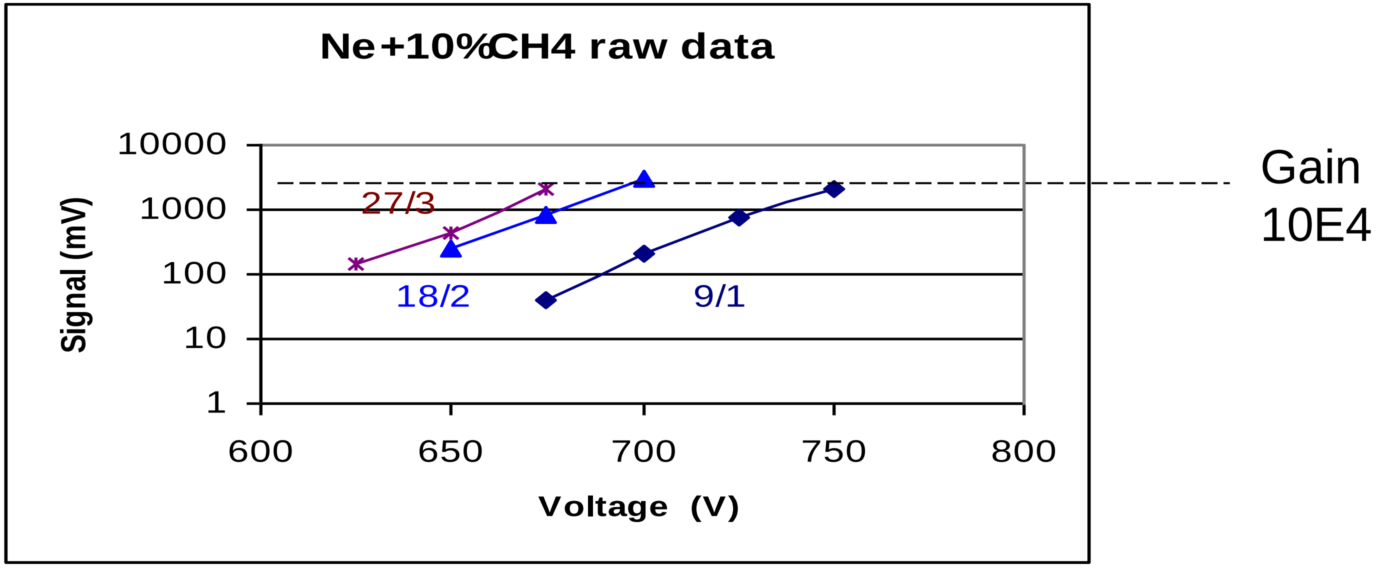
Ne+10%CH_4

(All data together, overlapping events, radiator thickness 10mm)



November 2010 beam test. Noise was removed offline

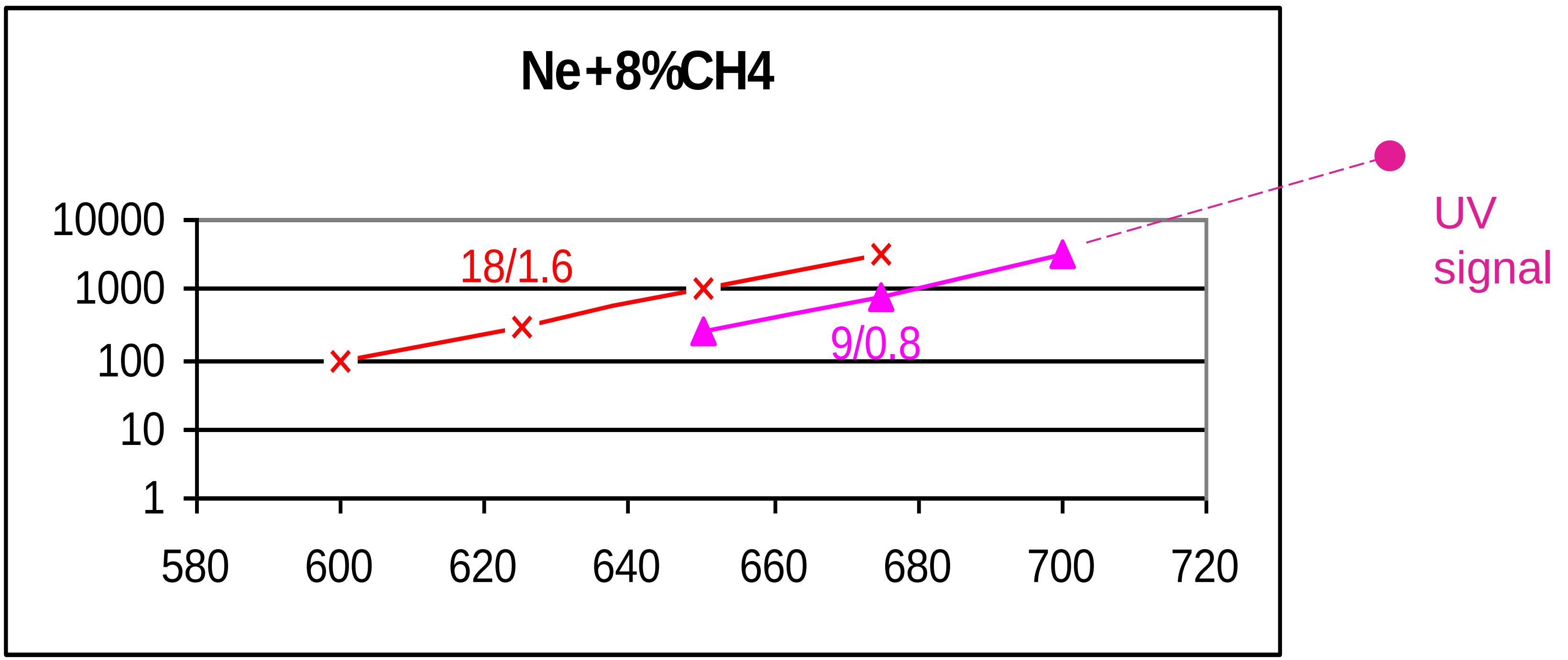
Measurements with ^{55}Fe



The gas flow at the beam test was 27/3

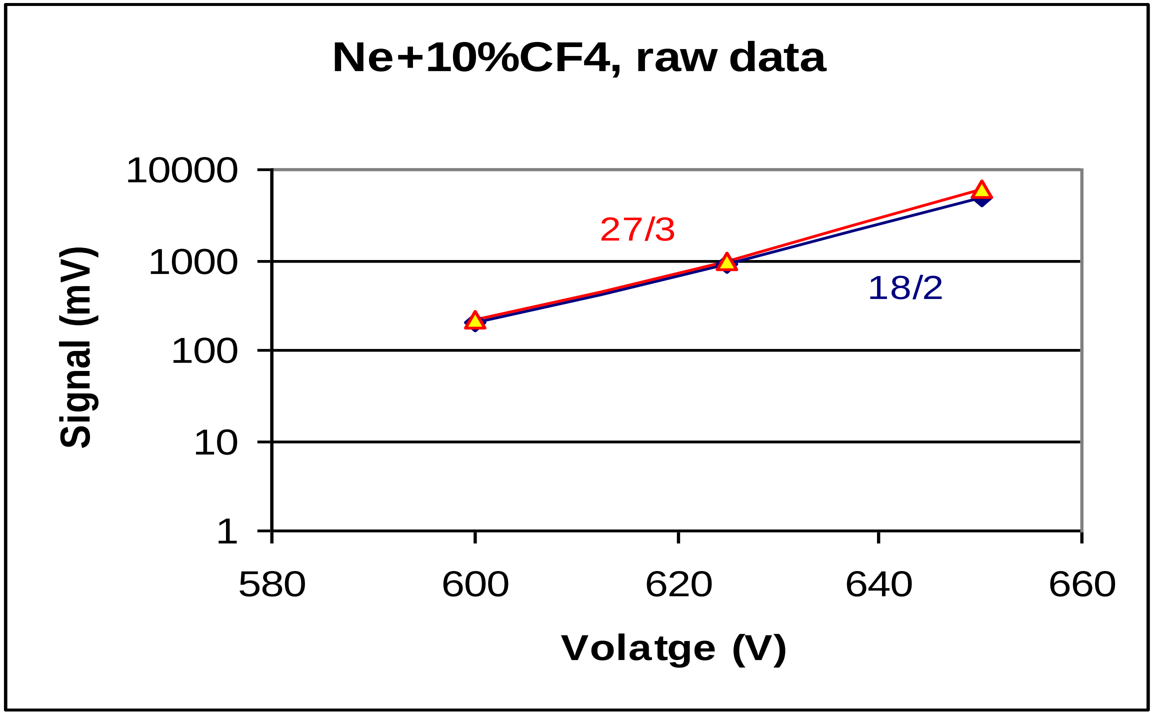
Measurements with ^{55}Fe

Gain 2x10E5



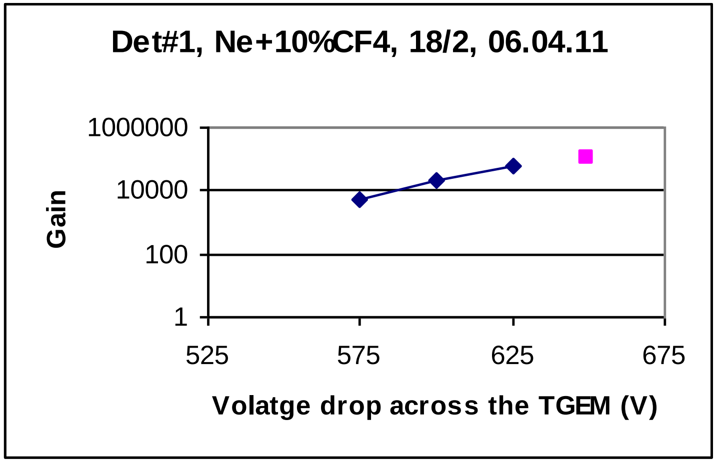
Today I am going to present results of **<u>the third (</u>**May 2011) beam test

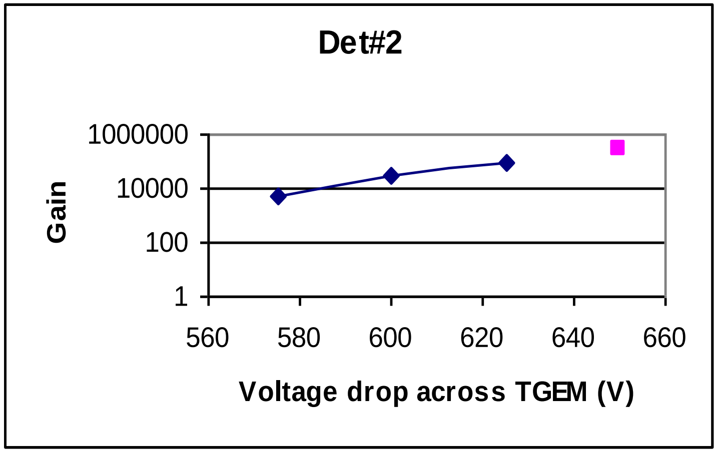
Laboratory tests



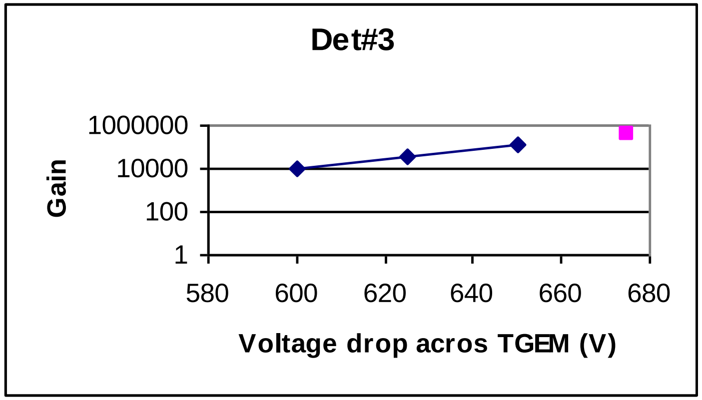
No flow dependence in the given region

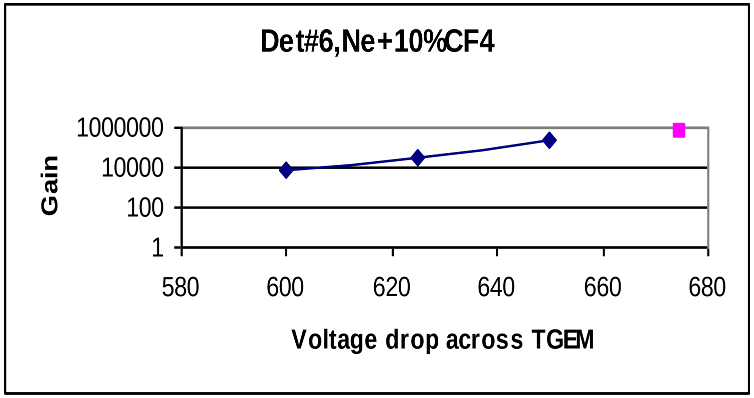
Typical results of gas gain measurements <u>for triple</u> CsI-TGEMs





Gains in the range 310^5-10^6 were achieved





Measurements were performed when the detectors were simultaneously irradiated with ^{55}Fe and UV light and ^{90}Sr source

Stability?

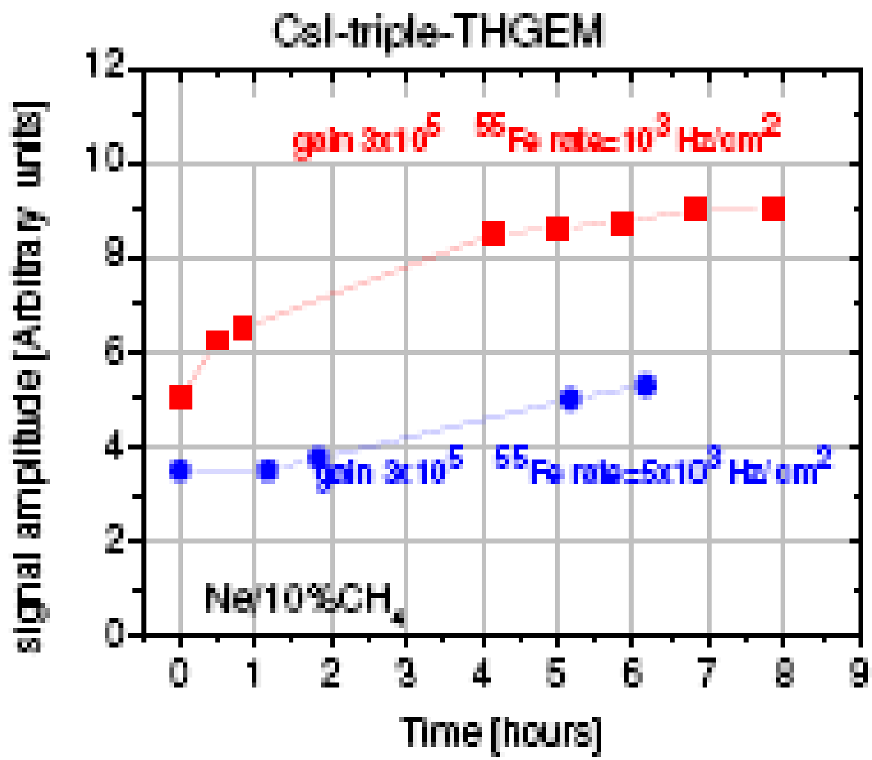
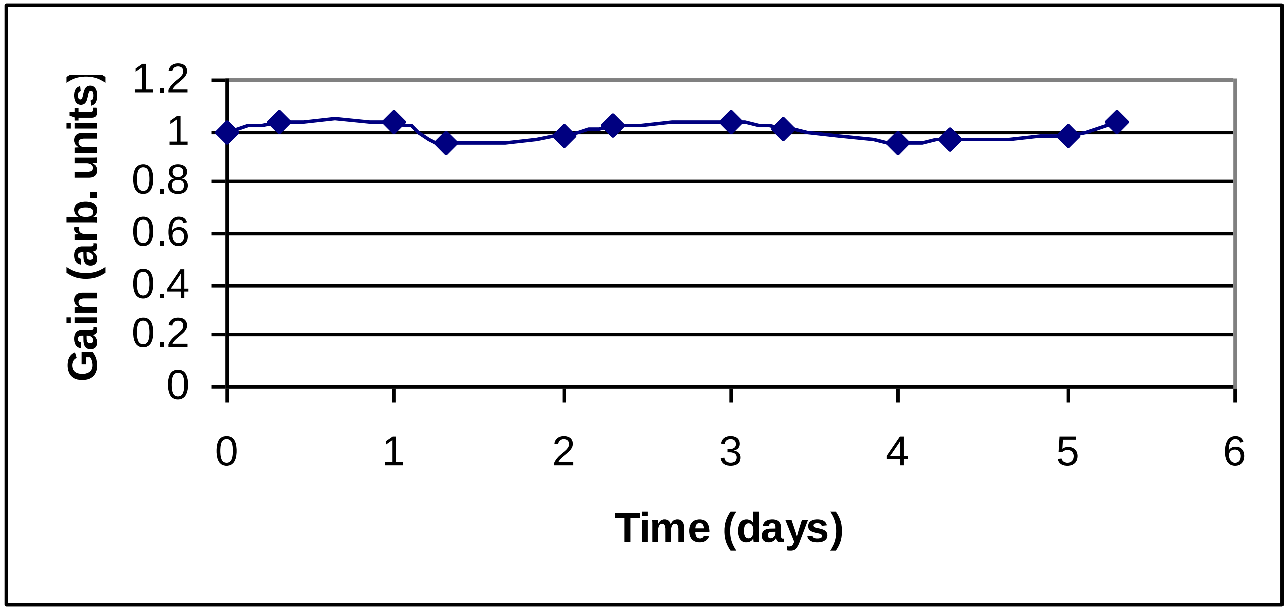


Figure 15. Short-term stability of a triple-THGEM (rim 0.1 mm) with CsI photocathode measured in Ne+10%CH_4 at a) at overall gain of 3×10^5 and counting rate of $\sim$ 1 kHz/cm^2 and b) an overall gain of 3×10^5 and counting rate of $\sim$ 5 kHz/cm^2.

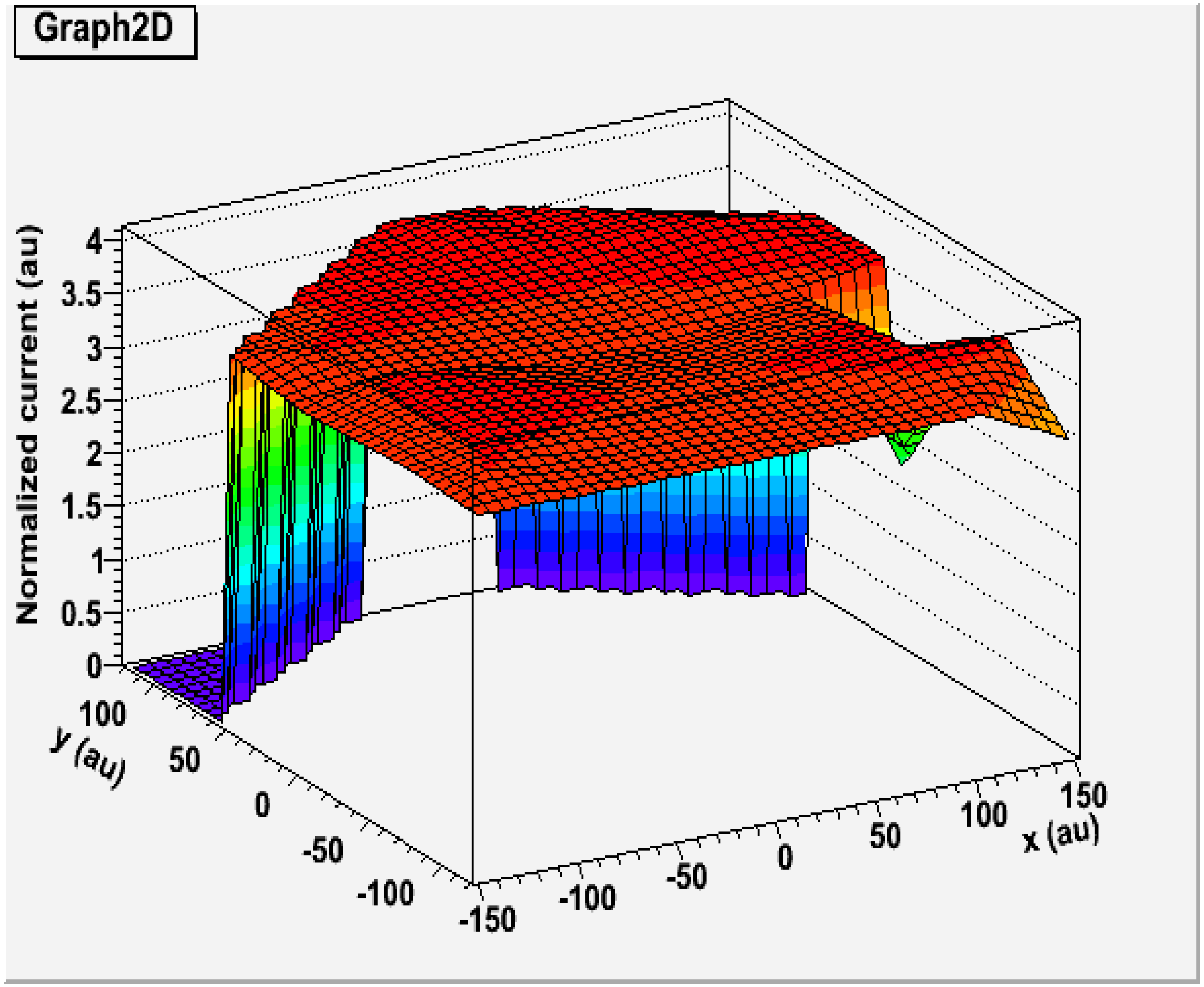
See, for example:V. Peskov et al ., JINST 5 P11004, 2010

We have <u>solved</u> the stability problems by constantly keeping some voltages over TGEMs



PS. The variations above correlated to the atmospheric pressure changes

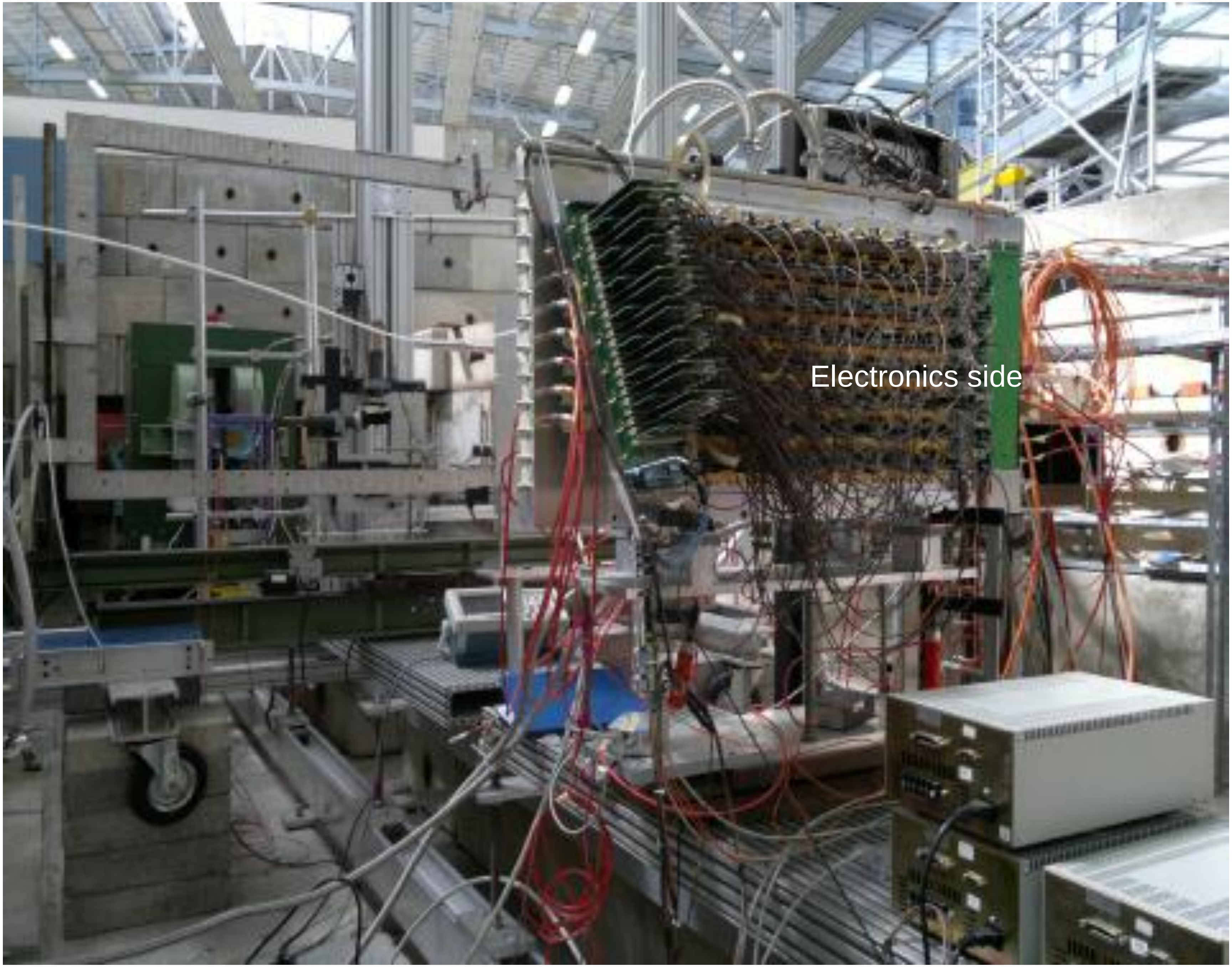
QE measurements before CsI-TGEM installation into the RICH prototype



The QE value is about 16% less than in the case of the best CsI-MWPC

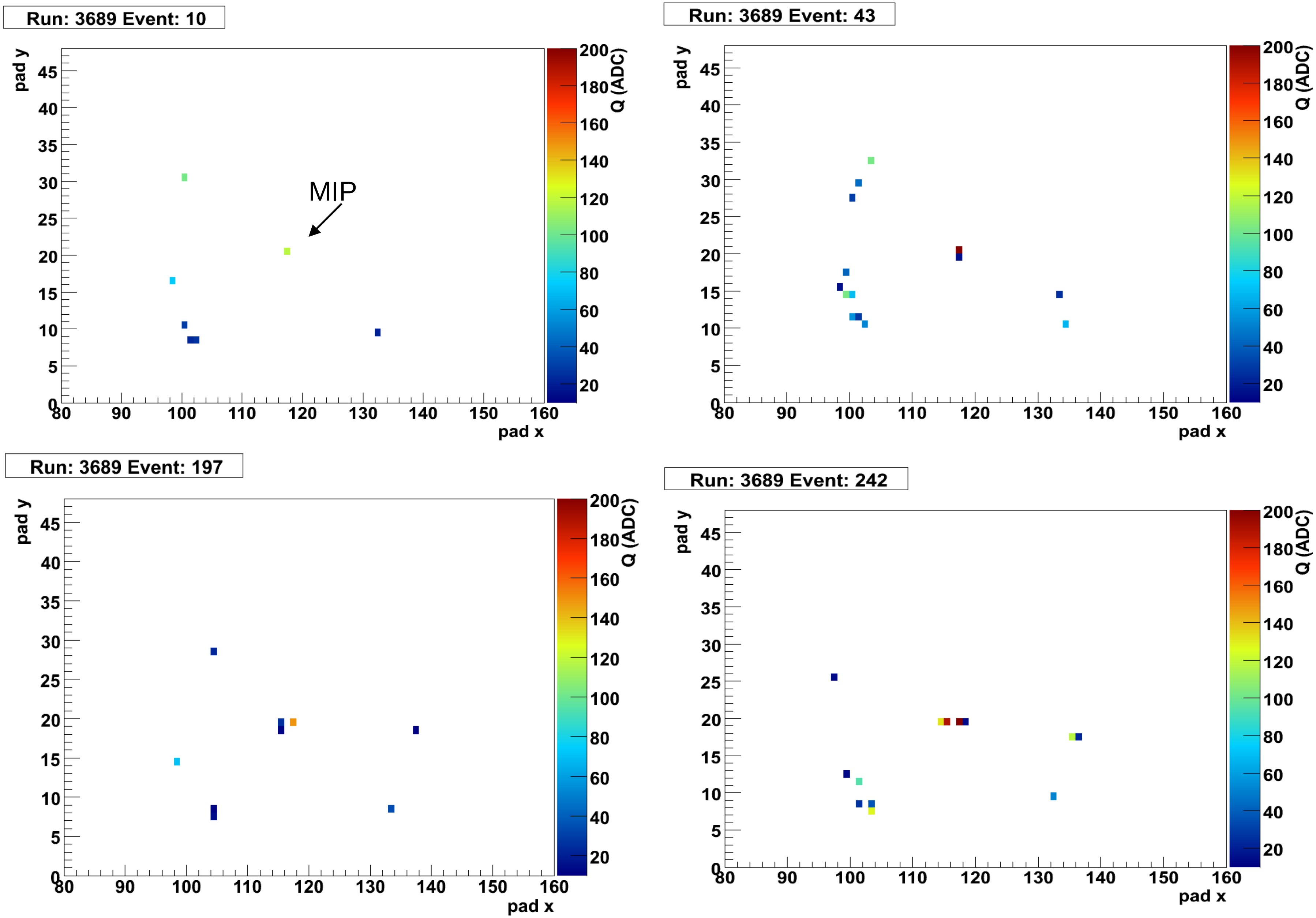
Beam test

Our proximity focusing TGEM-based RICH prototype installed at CERN T10 beam test facility (mostly ~6 GeV/c pions)

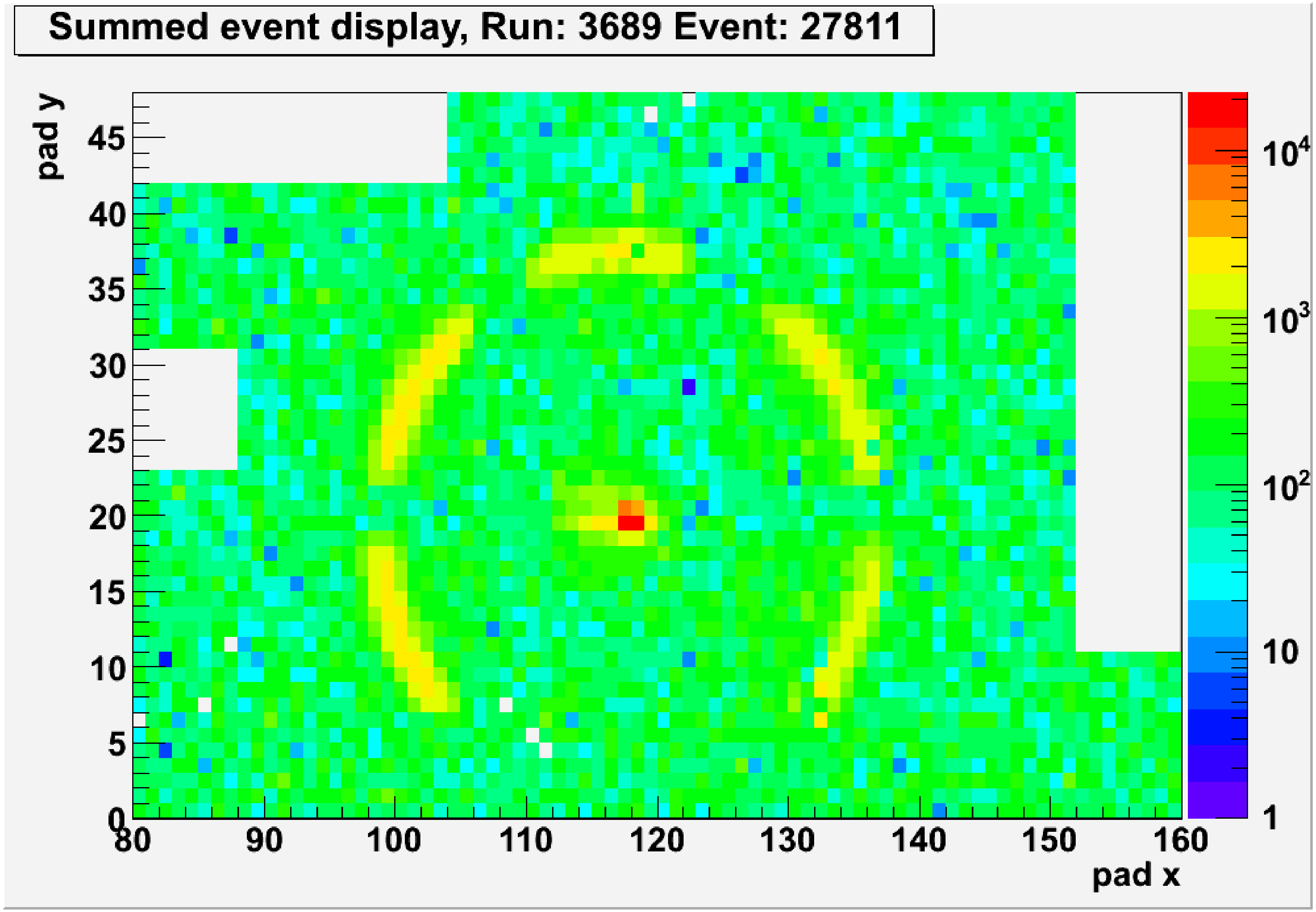

Electronics side

Some results

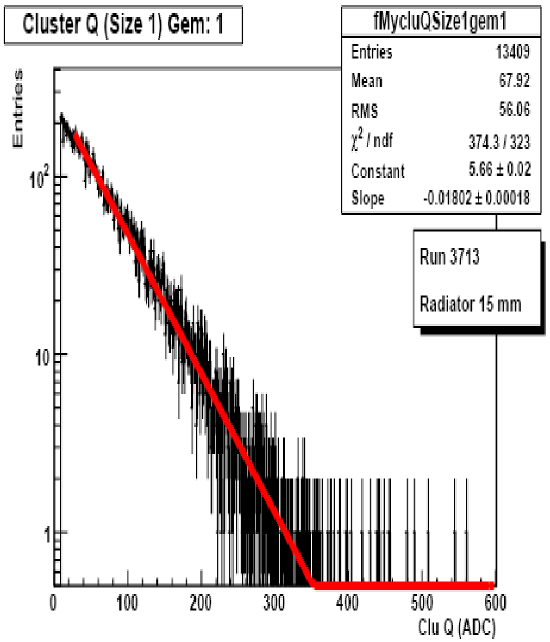
Single events display

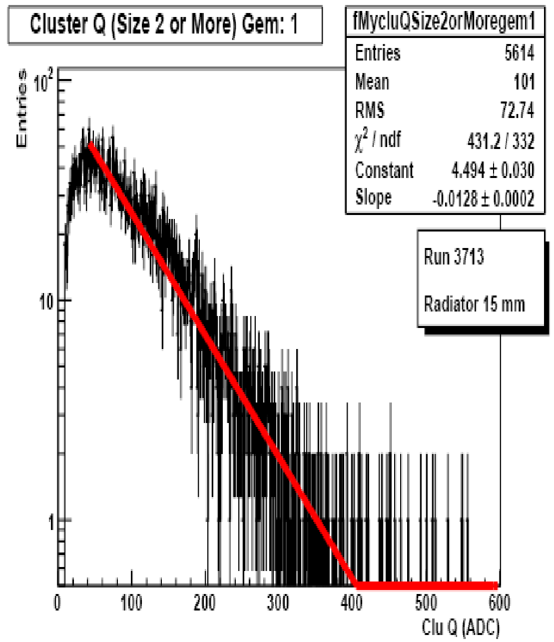


$Ne+10\%CF_4$ (overlapping events, rad. thickness 15 mm)

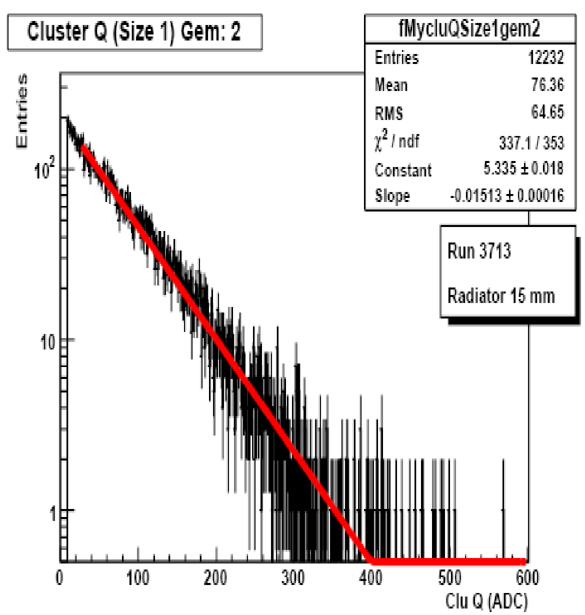


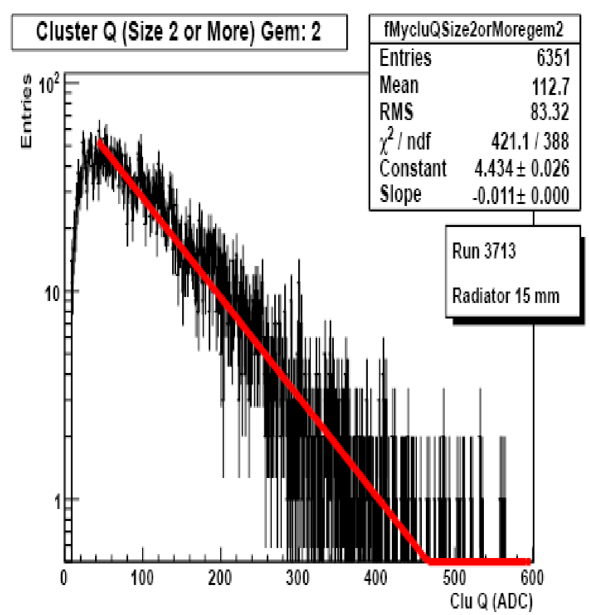
May 2011 beam test. Raw data, no noise removal





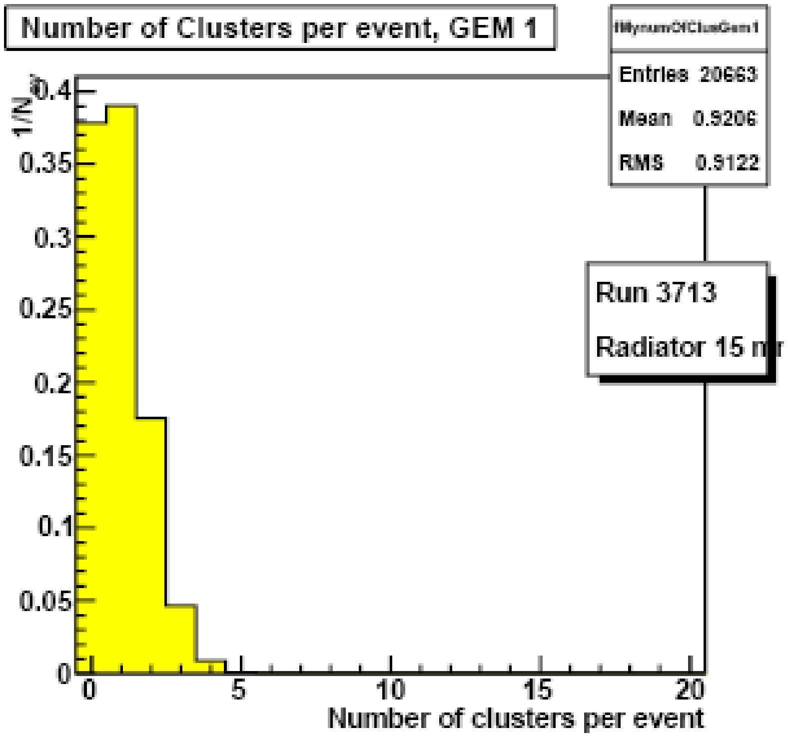
Overall TGEM gas gain ~1,4 x10^5

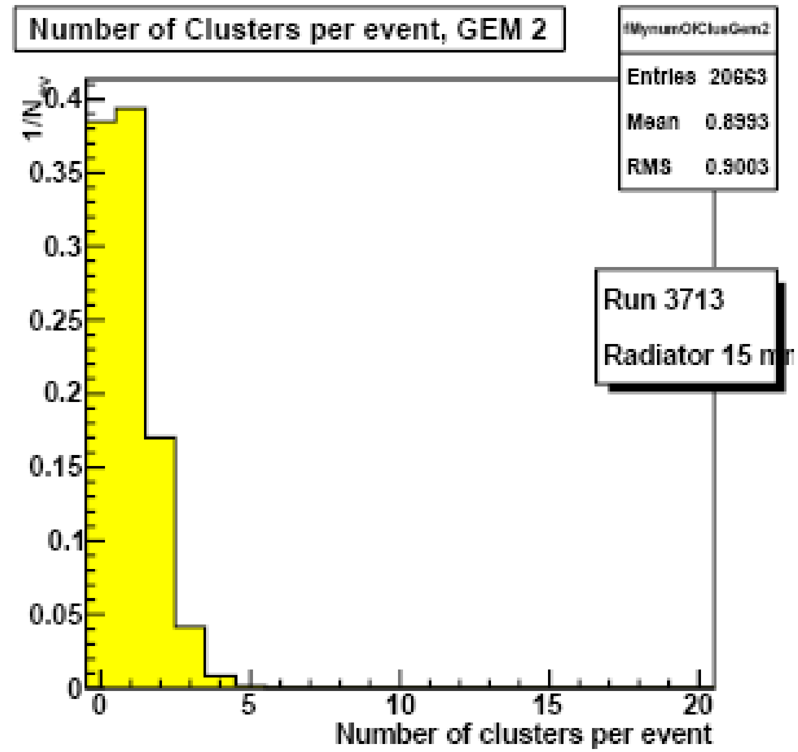




Radiator 15mm

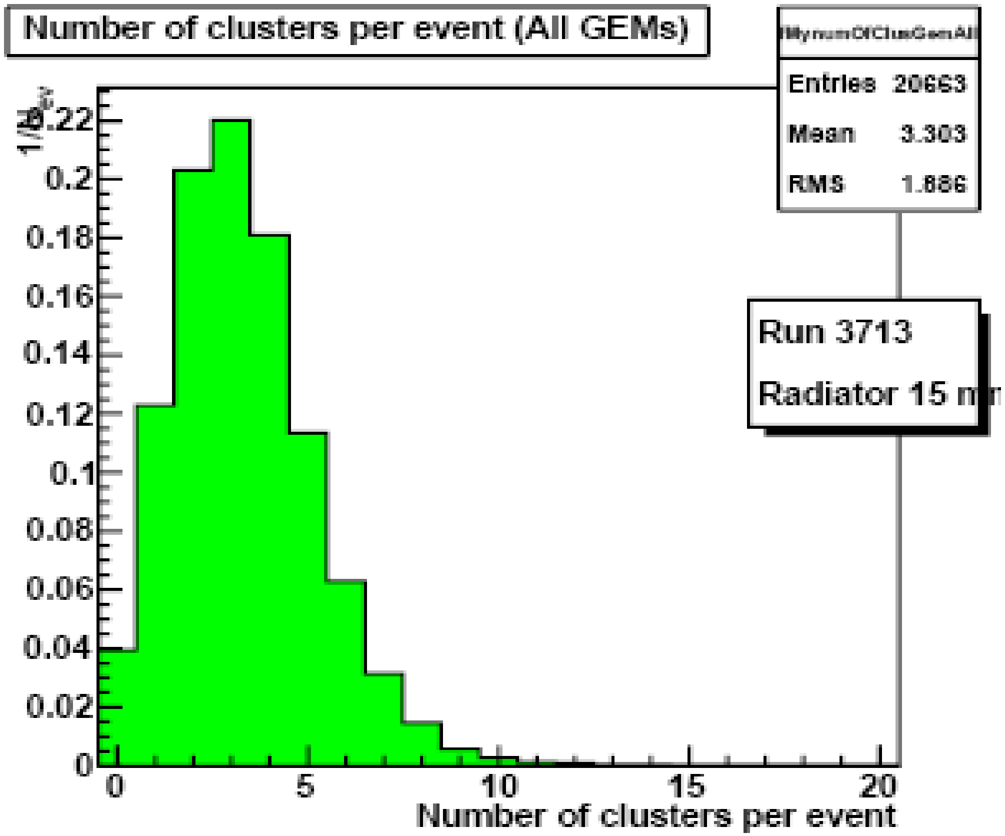
Some examples of data





Main conclusion : ~<u>1p.e. per TGEM</u>

Four triple TGEMs together



After corrections on geometry and nonuniformity of the detector response the estimated mean total number of photoelectrons per event is ~**10.**

What factors determined the TGEM QE?

$$Q_{TGEM} = Q_{vac}\, S_{eff}\, \varepsilon_{extr}(E,\lambda)\, \varepsilon_{\underline{coll}}(A)$$

- for a single TGEM

QE in gas

QE in vacuum

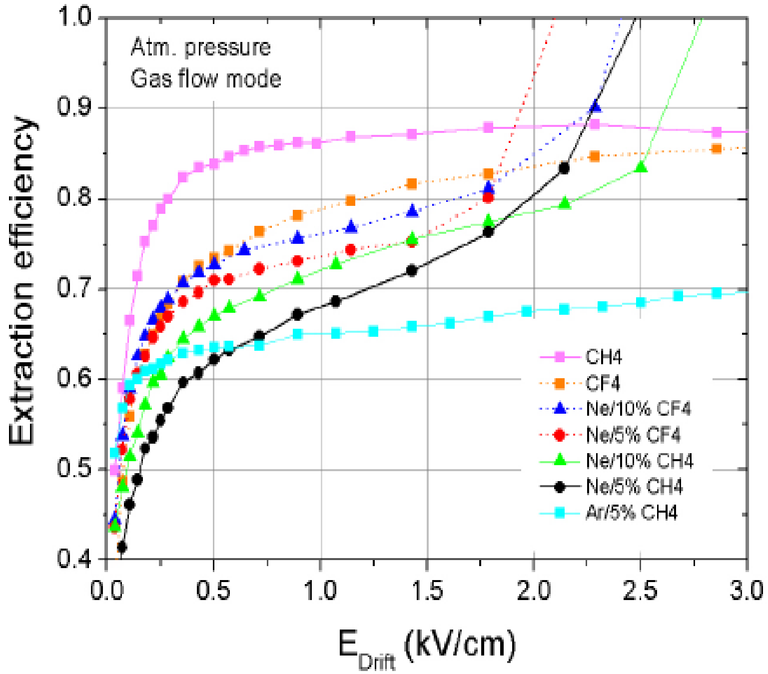
Active area

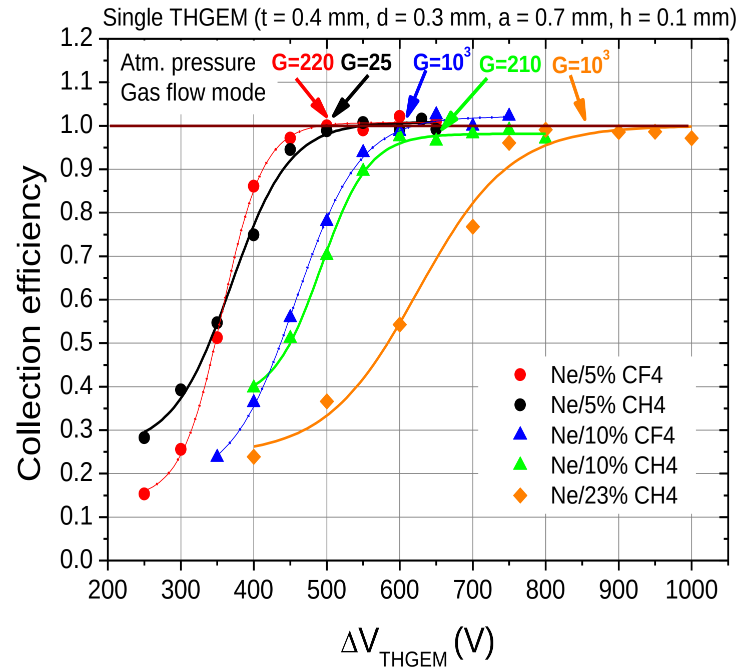
Fraction of photoelectrons extracted from PC **(depends on E and gas)**

Fraction of photoelectrons collected into the TGEM holes- **depends on gas gain**

$$N_{pe} = \int Q_{TGEM}(\lambda)\, I(\lambda) f_{pe}$$

$$f_{pe} \sim \exp(-A_{th}/A_0)$$





How much p.e one can expect in “ideal conditions”: full surface (without holes) and CH_4 gas:

Corrections: 0.9 (extraction)x0.75=0.68

10p.e/0.68~ **15pe**

What was achieved in the past with the CsI-MWPC (radiator 15mm)?

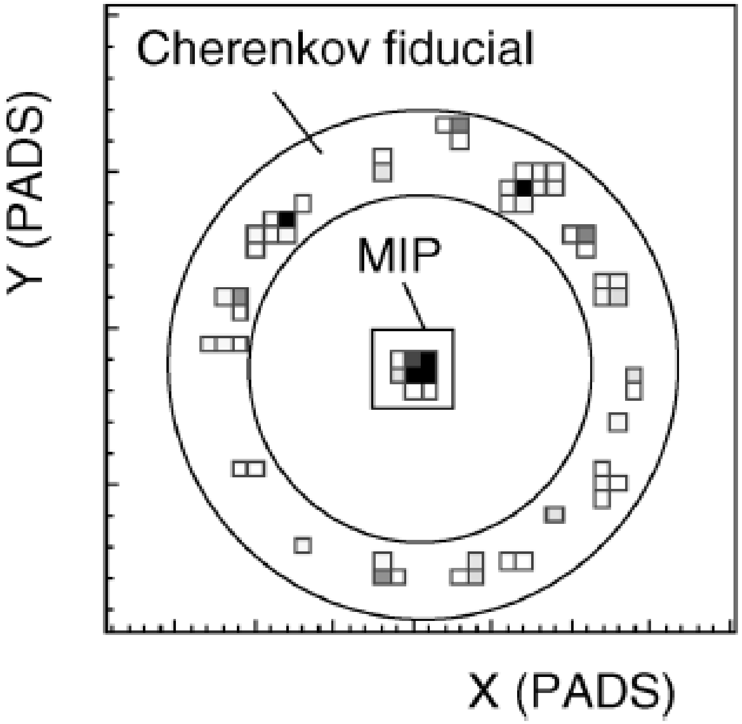
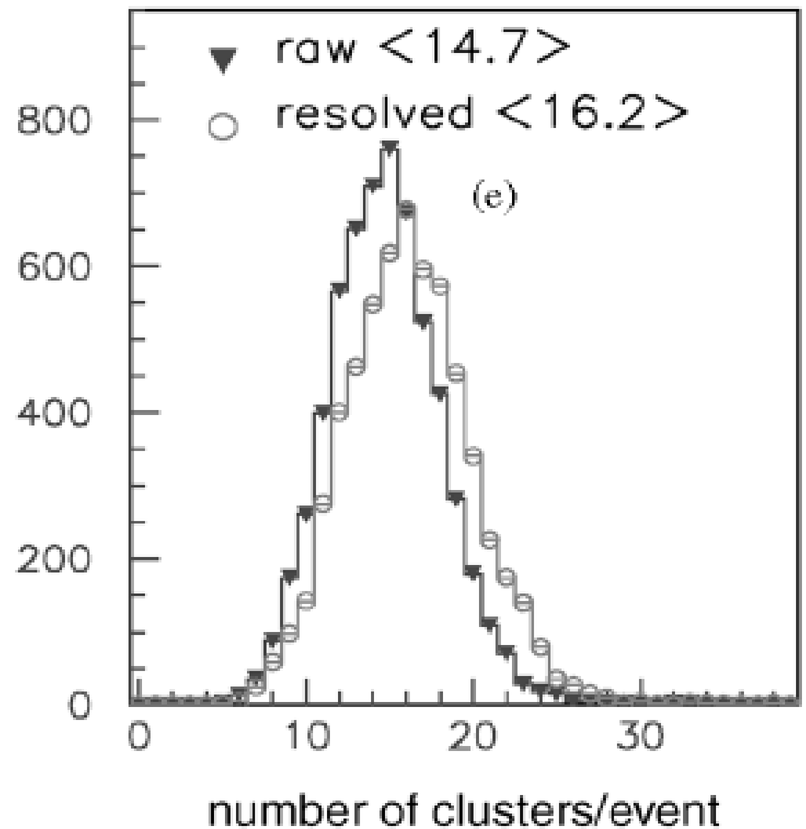
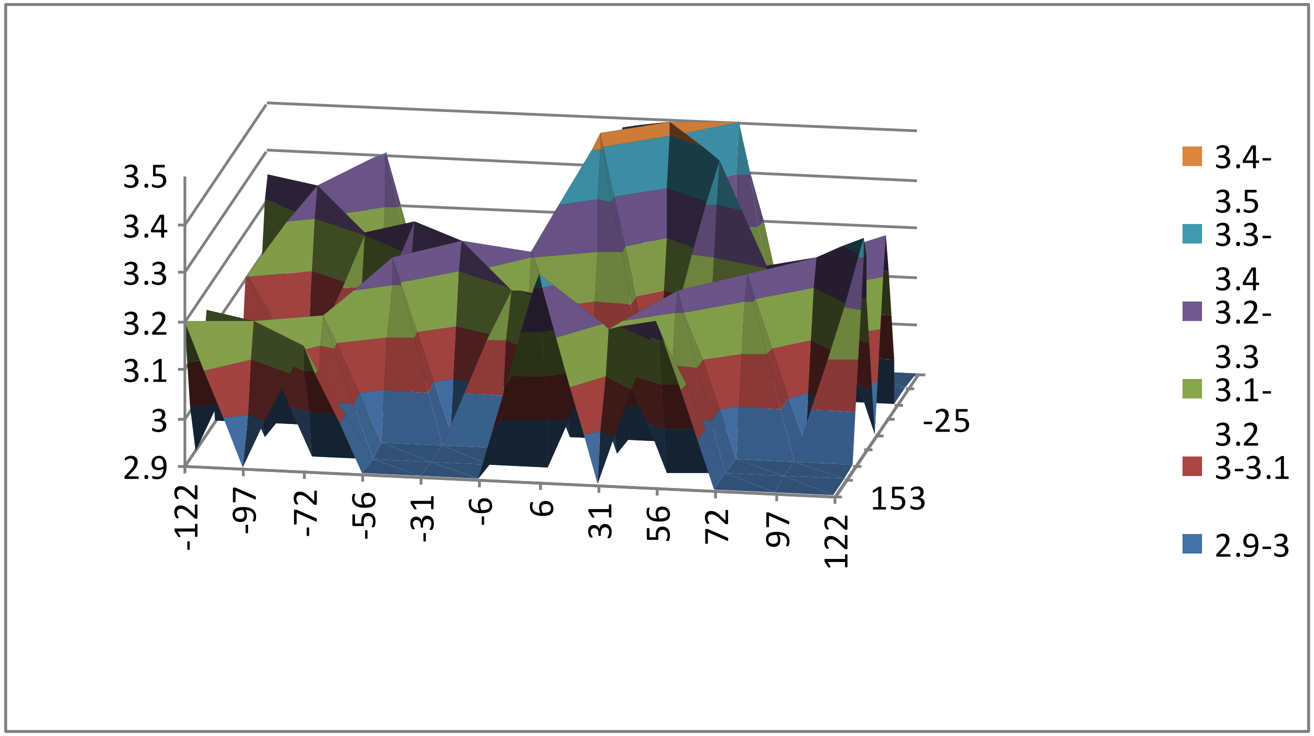


Fig. 3. Single Cherenkov ring event with the three zones used for cluster finding. A pad unit is $8 \times 8\ mm^2$.



F. Piuz et al., NIM A433,1999, 178

QE scan after the beam test



Conclusion from the scan: the QE of the CsI layer on the top of TGEMs is practically the same as before our tests - about 16% less than in the case of good MWPC

Developing the simulation program

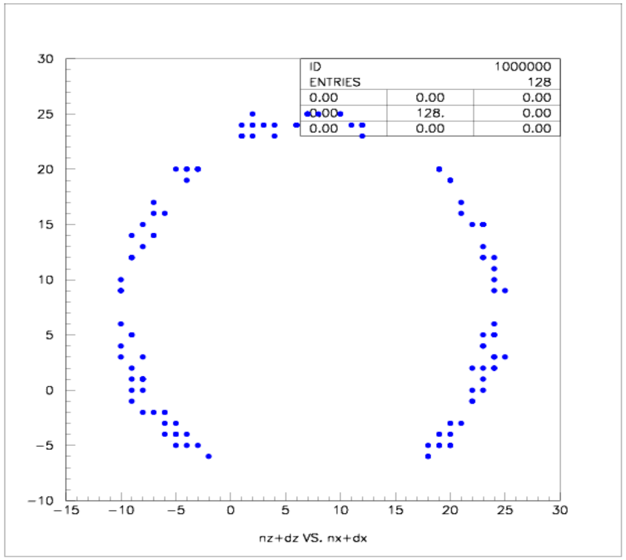
Some details, how simulation was done.

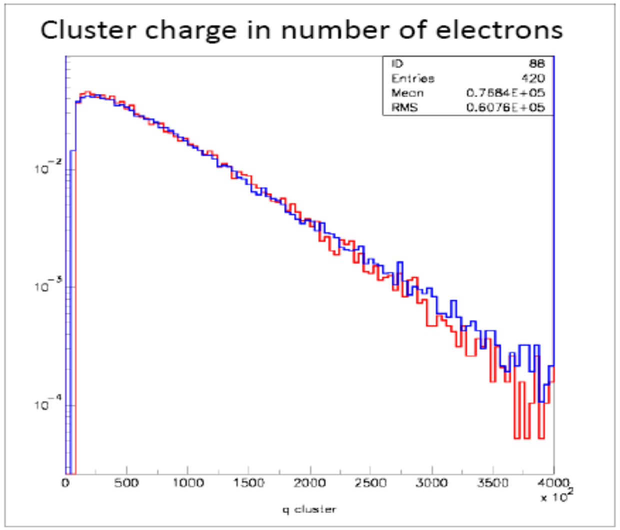
Input parameters: geometry, n-index, gas (ionization, diffusion), E-field, Average Gas Amplification, FEE parameters,…

- Primary ionization: track, Fe55 (position in a space of each e-), single photo-electron from CsI on a top of a first foil (GEANT-3 for UV production, transport and CsI QE)
- Transport of each e- to nearest hole in first foil (probability and position in a hole)
- Gas amplification; Polya distribution and “some special parameters”.
- Transfer of each e- after gas amplification step to next foil (hole selection)
- Repeat GA and Transport steps for second and third foil.
- Collect electrons on pad (strip) structure
- Add FEE noise and response for each (“active”) pad
- Threshold to select “active” pads.
- Cluster finding and reconstruction.

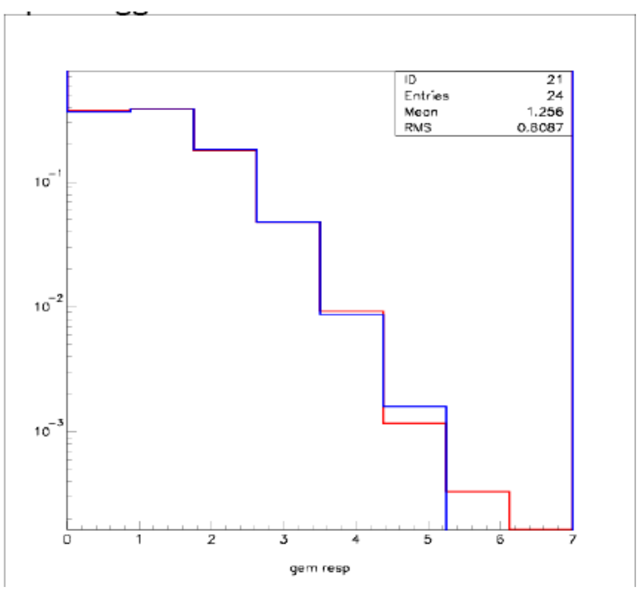
- NO Background (for the moment)

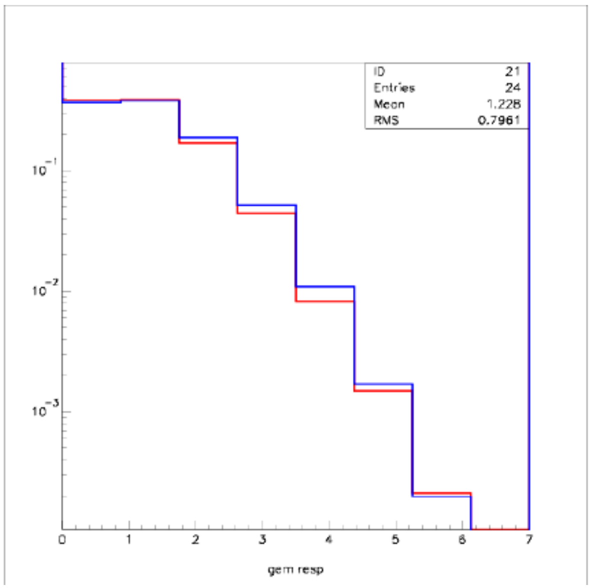
Some preliminary results of the simulation





Red-experimental data
Blue-calculations





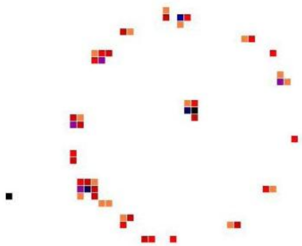
Number of reconstructed clusters per trigger (assumption QE=0.66QE in CH_4), so ~35% accuracy

We launched a program of the TGEM optimization:

asymmetric mode,

geometry optimization,

double CsI coated TGEM



Conclusions:

- With CsI-TGEMs we can now “routinely’ deetct cherenkov rings

- The mean number of detected photoelectrons is the same as expected from estimations

- Thus, preliminary It looks that TGEM is an attractive option for the ALICE VHMPID: it can operate in inflammable gases with a relatively high QE, it has a fast signals and cetera

- R&D prograkm is launched to optimize C-TGEMS for photon detection

- Of course, the final choice of the photodetector for VHMPID will be based on many considerations, for example MWPC approach has its own strong advantage: it is a well proven technology

Aknowledgments:

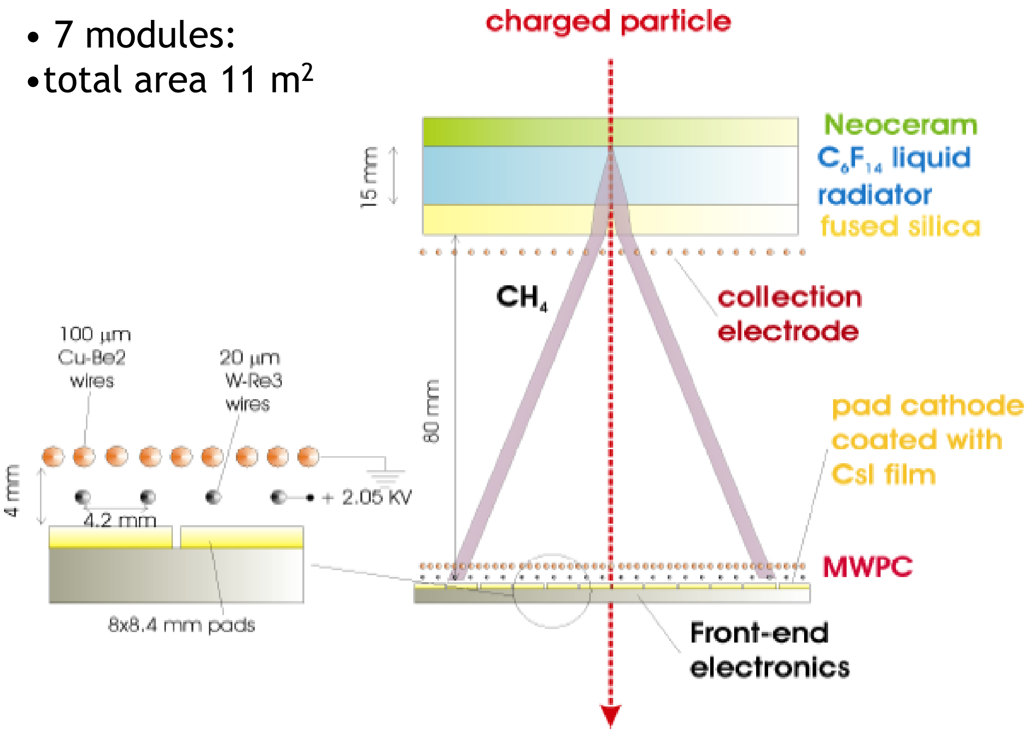
Author would like to thank J. Van Beelen, M. Van Stenis and M. Webber for their help throughout this work

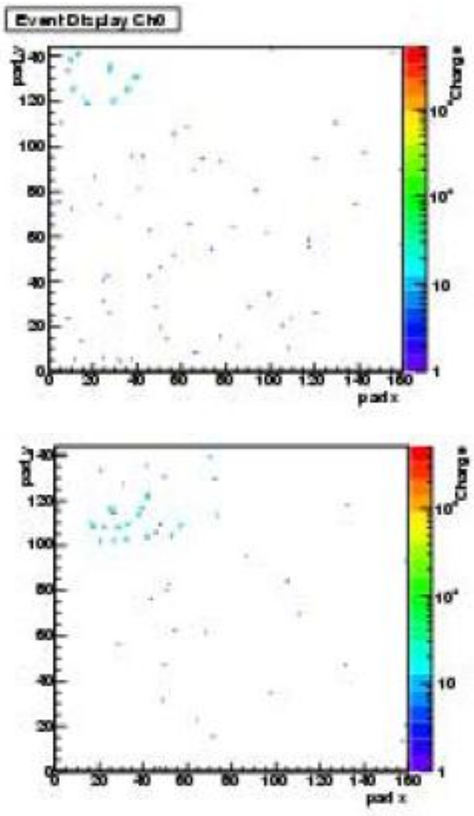
Spare

The main advantages of MWPC- it is a proven technology

The current ALICE/HMPID Detector

- 7 modules:
- total area 11 m^2

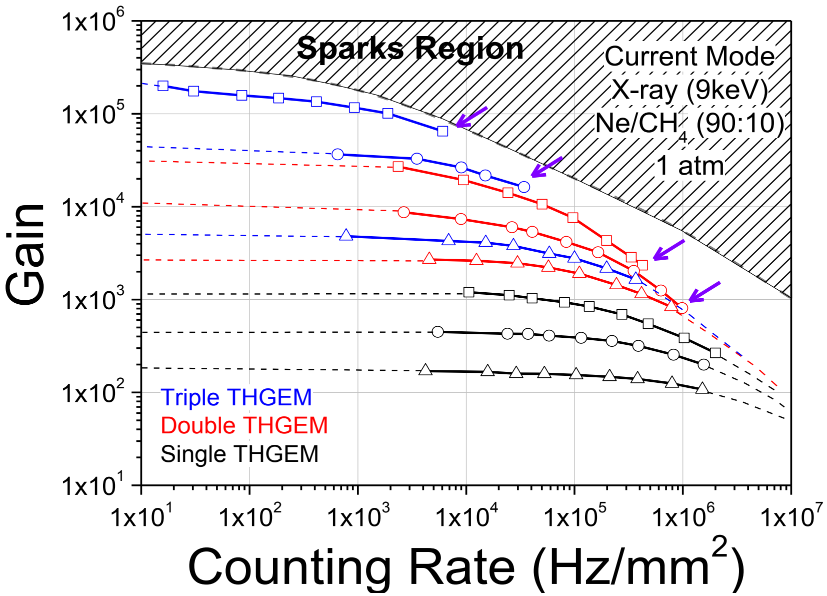


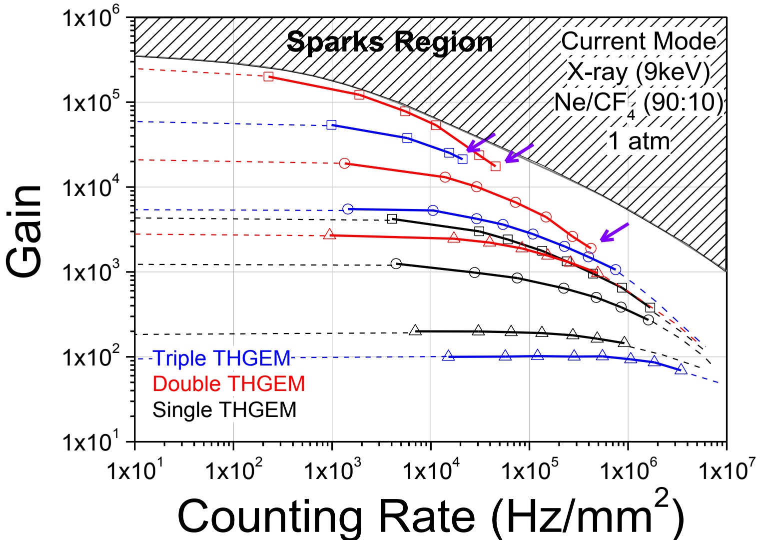


See A. Di Mauro talk at his Conference

First Cherenkov rings candidates at 7TeV proton-proton collisions at LHC

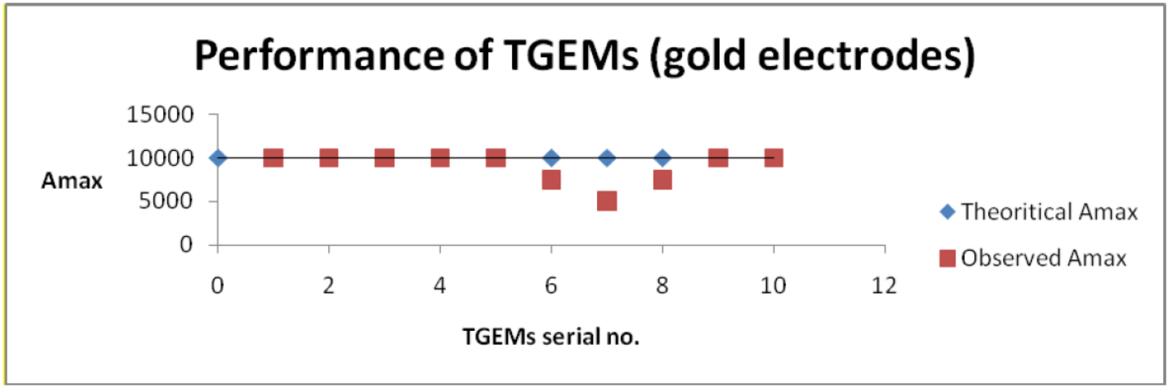
Rate dependance

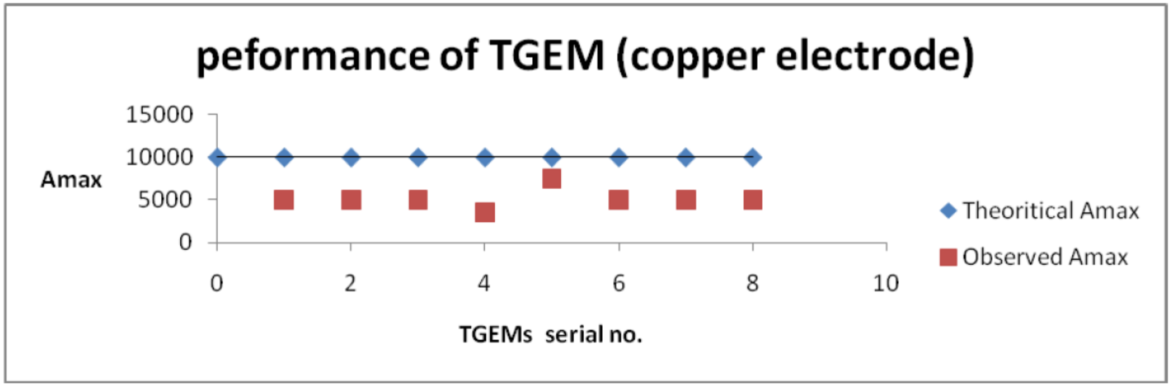


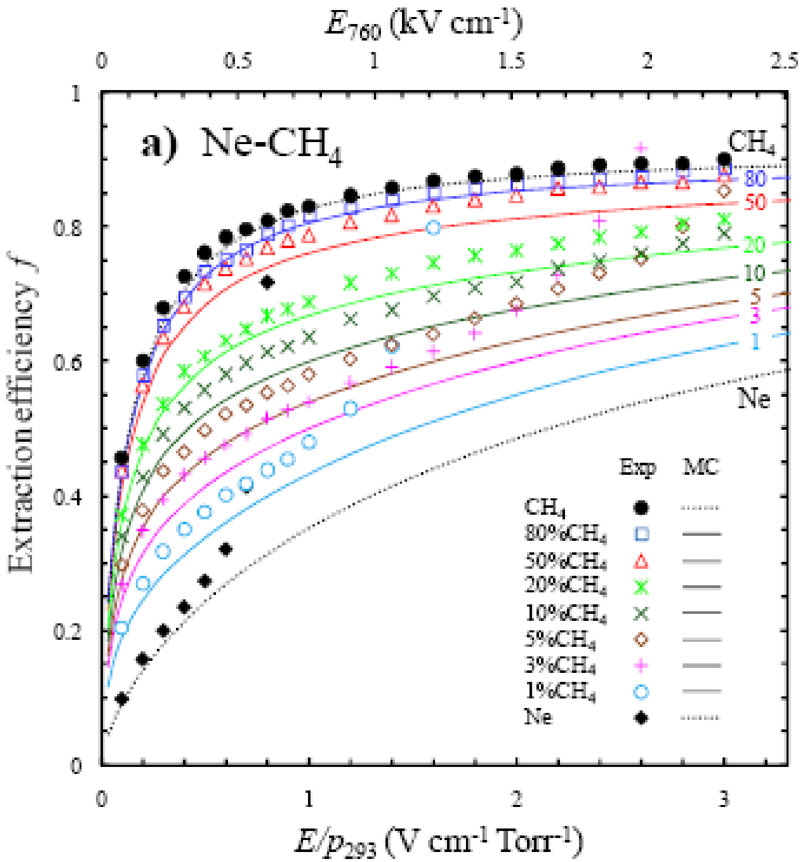


Triple TGEM is inside this general limit!.. So at the beam test we should not expect an unlimited gain

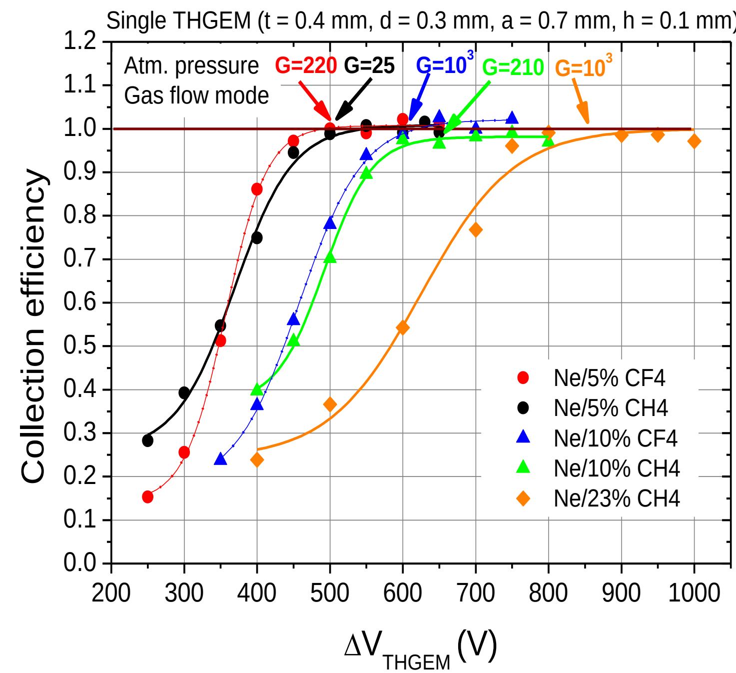
Summary of single TGEMs performance







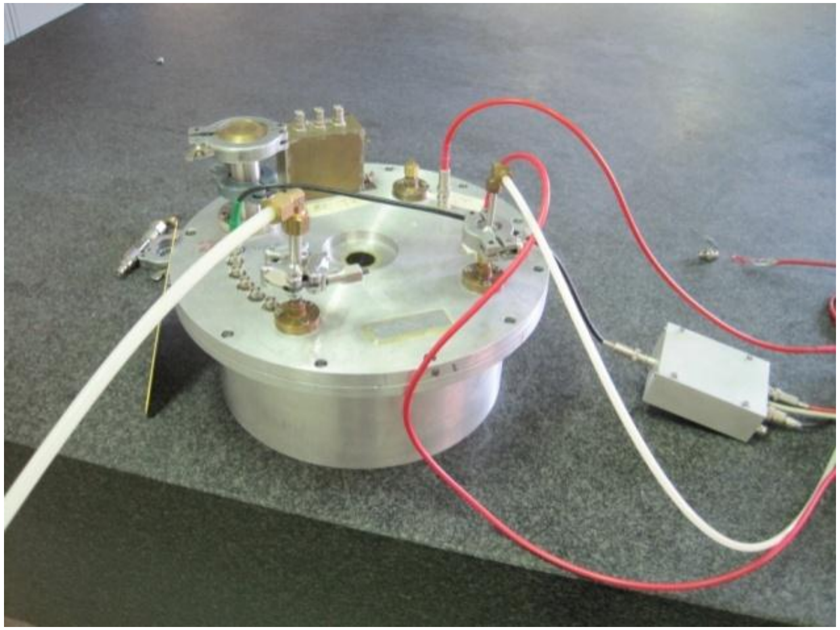
E_{extr} measurements



E_{coll} measurements

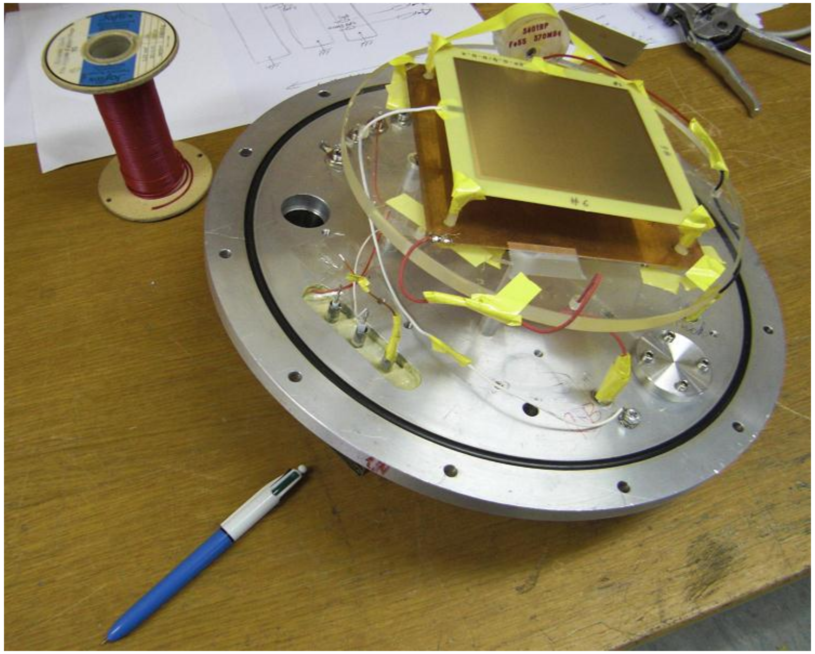
J. Escada et al., JINST 4:P11025,2009

*C. Azevedo , et al., 2010 JINST **5** P01002*



Before the installation to the RICH detector, each TGEM was individually tested in a separate small gas chamber.

In these tests we mainly identified the maximum achievable gains when the detectors were irradiated with the ^{55}Fe source and with the UV light.



Version 17.0

EUROPEAN LABORATORY FOR PARTICLE PHYSICS

CERN-ALICE-2011-00X
ALICE-I-XXX
November, 17 2011

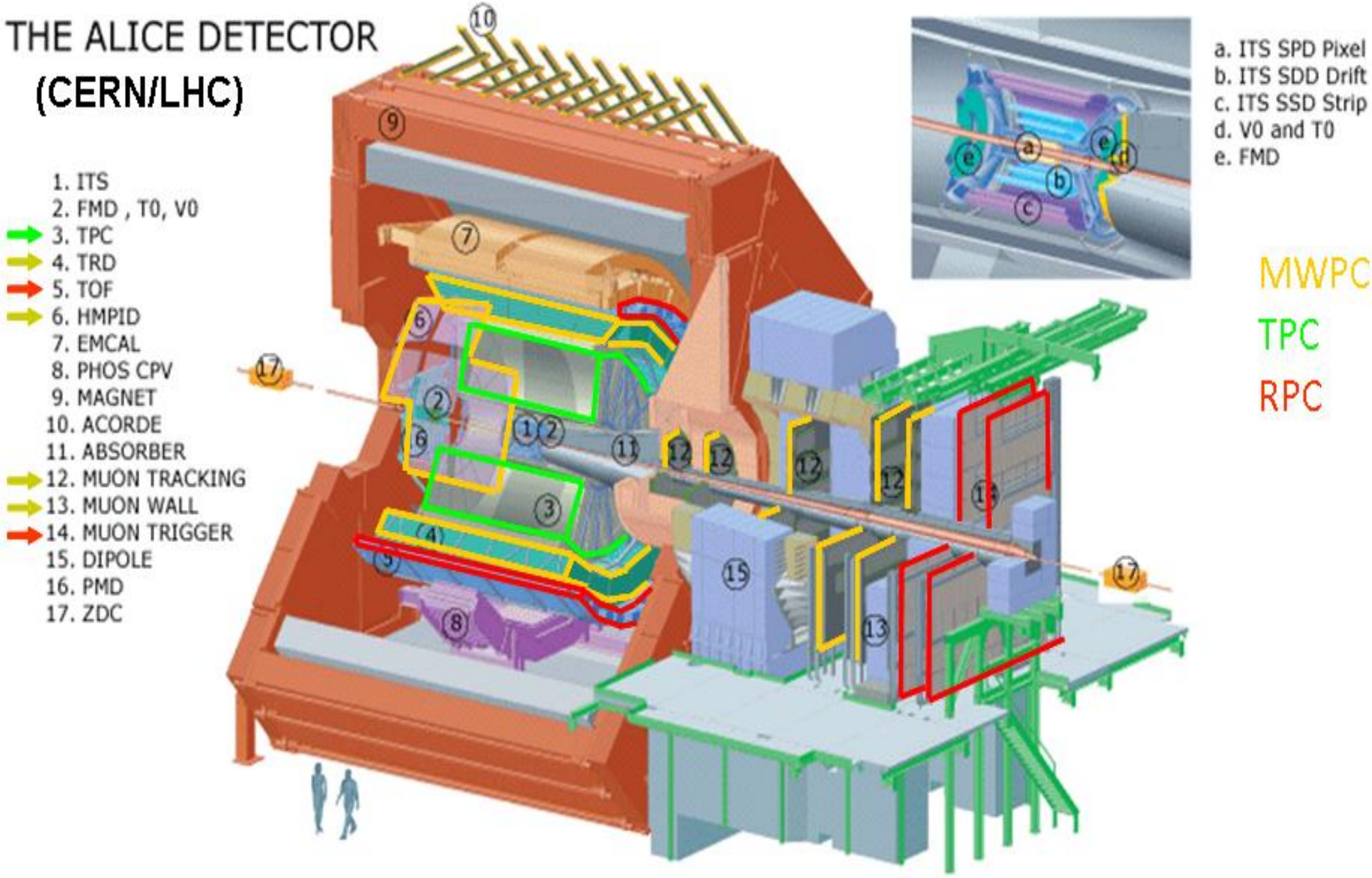
Letter of Intent

A Very High Momentum Particle Identification Detector (VHMPID) for ALICE

By the participating institutions

electronic version:
https://twiki.cern.ch/twiki/bin/view/Sandbox/VHMPIDLoI

Oou team preaperd and is plannin to submite in aseveral weeks from now to ALICE managment an LOI suggestion to build a new RICH detector for ALICE upgrade



THE ALICE DETECTOR
(CERN/LHC)
1. ITS
2. FMD , T0, V0
3. TPC
4. TRD
5. TOF
6. HMPID
7. EMCAL
8. PHOS CPV
9. MAGNET
10. ACORDE
11. ABSORBER
12. MUON TRACKING
13. MUON WALL
14. MUON TRIGGER
15. DIPOLE
16. PMD
17. ZDC
a. ITS SPD Pixel
b. ITS SDD Drift
c. ITS SSD Strip
d. V0 and T0
e. FMD
MWPC
TPC
RPC

All data together, cleaned up